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THE SPREAD OF POTATO VIRUS Y IN SEED POTATOES IN RELATION TO THE DATE OF HARVESTING AND THE PREVALENCE OF APHIDS[1]

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ABSTRACT

In order to determine the effect of controlling aphids with DDT and of the early harvesting of potatoes on the spread of potato virus Y, two row plots of Green Mountain potatoes, arranged in 6 × 6 Latin Squares were grown in 1949 and 1950. The plots were interspaced with rows of virus Y infected potatoes. Some of the plots were sprayed with 2 pounds Deenate 50W in 100 gallons of water per acre, and others were left untreated as checks. A 100-tuber sample was saved from each plot to be planted the following year for disease readings.

Seven per cent of the tubers had become infected with virus Y by August 10 in 1949 and 19 per cent by the same date in 1950, gradually increasing to 14.3 per cent by September 14 in 1949 and 32.3 per cent by the same in 1950.

Aphids were first detected on July 26 in both years, and maximum populations occurred early in September. Aphid populations were greatly reduced in the treated plots, compared to those in the check plots, but the spread of virus Y was not lessened. Much of the spread had already occurred well before maximum aphid populations had been reached.

The proportion of seed tubers infected, the activity and probably the species of aphids present during different periods of the season, appear to have more bearing upon the spread of potato virus Y than the total number of aphids.

Early harvesting of potatoes to control virus Y would not be economical in the Fredericton district, according to the results obtained in these experiments. On the other hand, early and thorough roguing of infected plants, together with adjacent, apparently healthy plants, is indicated as the means of controlling the virus.

INTRODUCTION AND REVIEW

The control of virus diseases in potato crops has long represented an intriguing challenge. The removal of diseased plants, or roguing, was known to be of some value many years before the causal agents were known. Once the virus origin of leaf-roll was established by Orton in 1913 and the possibility of the disease being transmitted by aphids was suspected, the field was opened for experimentation with early harvesting and top removal, measures designed to effect a timely separation of the tubers from their vines once aphids have arrived in the potato fields from their spring hosts. This practice involved a sacrifice in yield but assured a supply of healthy seed for the following year's crop.

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Botjes (1) proved that the leaf-roll virus was transmitted by aphids, and Quanjer (14) obtained a similar proof for what is now known as potato virus Y. Schultz and Folsom (17) found that less mosaic was transmitted through seed pieces if the tubers were harvested before aphids became abundant. Salaman (15) suggested that seed potatoes harvested when immature might be preferable to those harvested when mature, because the former had escaped infection.

These early observations led to some more searching experiments. Schultz and Folsom (18) found that the digging of selected healthy hills progressively later in the season was correlated with a higher incidence of mosaic disease in the progeny. Botjes (2) reported one per cent mosaic in plants from tubers which had been harvested on July 11 the previous year, as compared with 4, 6, 15, and 30 per cent in plants from tubers harvested on July 20, 24, 29, and August 3, respectively. Murphy and McKay (13), Ducomet (9), and Münster (12) all reported favourable results with early harvesting of seed potatoes. The convincing results of these experiments led to widespread interest and the general acceptance of the principle that early harvesting limited the amount of virus infection in potato tubers.

Schultz and his co-workers (16) continued their investigation of this problem during the period 1925 to 1927, and from 1935 to 1943. They concluded that the mild mosaic (potato virus A), leaf-roll, and spindle tuber viruses seldom penetrate into the tubers of Green Mountain plants before the first of August, although considerable infection might occur later in the season.

Doncaster and Gregory (8) studied the spread of virus diseases in potatoes in Eastern England during the period 1940 to 1945. They found that there was a substantial spread of rugose mosaic, of which virus Y is the aphid-borne component, after the first of August, in only about 10 per cent of the potato crops surveyed. A substantial increase in the amount of leaf-roll infection occurred after this date in 30 per cent of these crops (mainly the Majestic variety). Maximum aphid populations were not reached until August. They concluded that in this part of England much of the spread of virus diseases in potatoes occurred early in the season, before the plants had set tubers sufficiently to make early harvesting economical.

Conners and Savile (6) reported evidence that the spread of mosaic depends more upon the amount of initial infection in the seed than upon aphid population to which the crop is currently exposed. Fluctuations in the aphid population from year to year appeared however, to have some effect upon the spread of leaf-roll. The term "mosaic" here would include rugose mosaic and mild mosaic, as well as a number of less common diseases.

While some workers were advocating the early harvesting of the crop, others theorized that the destruction of the aphids would be a more practical means of controlling virus diseases. Little success, however, has attended efforts to reduce the spread of virus diseases by the destruction of aphids after they had reached potato fields. Kotila (10), in Michigan, found that careful roguing and spraying with nicotine sulphate throughout the season failed to eliminate the spread of rugose mosaic and leaf-roll. Doncaster

and Gregory (8) reported that fumigating with nicotine vapour destroyed large numbers of aphids, but had no effect on the spread of virus diseases. They concluded that there was little correlation between the total aphid population and the spread of leaf-roll, and none whatever with respect to the spread of rugose mosaic.

The period during which aphid-borne viruses are spread, and consequently the best time to harvest seed potatoes in order to prevent virus infection, have been found to vary from locality to locality and from one season to another. In 1949, a series of experiments was initiated at Fredericton, N.B., to study the trends in virus spread at different periods during the growing season. At the same time, an effort has been made to determine the effect of reducing the aphid population by means of DDT insecticide.

EXPERIMENTAL METHODS

Three experiments were conducted to determine the period during which potato virus Y (*Solanum Virus* 2, Smith) is spread in the field and the effect of controlling aphids upon this spread. Healthy Green Mountain potatoes were planted in replicated plots arranged in 6 × 6 Latin Squares; each plot consisted of two rows 40 feet long. Any residual infection with virus Y was eliminated by early season roguing. In order to expose the plots as uniformly as possible to infection with virus Y, a row of Green Mountain potatoes infected with this virus was planted between the first and second plots, the third and fourth plots, and the fifth and sixth plots. Therefore, each Latin Square consisted of a block 15 rows wide and 255 feet long, with 3-foot cross-alleys between each of the 40-foot ranges.

Experiment I, consisting of a single Latin Square as described above, was planted on June 6, 1949. Three of the replicated series of plots (18 plots in all) were sprayed seven times at approximately 10-day intervals with DDT, 2 pounds of Deenate 50W in 100 gallons of water per acre, commencing on July 6 and terminating in the first week of September. A 10-5-100 Bordeaux Mixture was applied with the DDT sprays as a fungicide. The remaining three series of replicated plots (also comprising 18 plots) were not treated with DDT, receiving only the fungicide, and are designated as check plots. One DDT-treated series of plots, and one check series were harvested on the following dates: August 22, September 12, and October 3.

Experiment II was also planted on June 6, 1949, and it too, consisted of a single Latin Square. All six series of replicated plots (36 plots in all) were sprayed with DDT and the fungicide, as previously described. One series of plots was harvested on each of the following dates: August 10, 17, 24, 31, September 7 and 14.

Experiment III, planted on June 8, 1950, was a combination and enlargement of Experiments I and II. It consisted of four 6 ×6 Latin Squares, two of which received the DDT and fungicide treatment, commencing on July 7 and terminating in the first week of September. The other two Latin Squares were not treated with DDT, but received only the fungicide, and their plots are designated as checks. One series of replicated plots from each Latin Square (12 plots sprayed with DDT and 12 check plots) were harvested on each of the following dates: August 10, 17, 24, and 31, and September 7 and 14.

TABLE 1.—*Experiment I:* RELATIVE POSITION OF PLOTS IN 6 × 6 LATIN SQUARE; TREATMENT (DDT OR CHECK), HARVESTING DATE, AND NUMBER OF PLANTS INFECTED WITH POTATO VIRUS Y IN EACH PLOT. ROWS RUN LEFT TO RIGHT (EAST TO WEST) IN THIS AND SUBSEQUENT EXPERIMENTS

DDT Oct. 3	*5*	C Oct. 3	*11*	DDT Aug.	9	C Aug. 22	*9*	C Sept. 12	*11*	DDT Sept. 12	*30*
DDT Sept. 12	5	C Sept. 12	5	DDT Oct. 3	*15*	C Oct. 3	*22*	DDT Aug. 22	*19*	C Aug. 22	*29*
C Sept. 12	5	C Aug. 22	*2*	DDT Sept. 12	*15*	DDT Oct. 3	*9*	C Oct. 3	*21*	DDT Aug. 22	*29*
C Aug. 22	*1*	DDT Oct. 3	*15*	C Oct. 3	*8*	DDT Aug. 22	*22*	DDT Sept. 12	*17*	C Sept. 12	*38*
C Oct. 3	*9*	DDT Aug. 22	*3*	C Sept. 12	*11*	DDT Sept. 12	*7*	C Aug. 22	*13*	DDT Oct. 3	*20*
DDT Aug. 22	*13*	DDT Sept. 12	*16*	C Aug. 22	*13*	C Sept. 12	*15*	DDT Oct. 3	*15*	C Oct. 3	28

TABLE 2.—*Experiment I:* PERCENTAGE OF RUGOSE MOSAIC IN DDT-TREATED PLOTS AND CHECK PLOTS HARVESTED ON THREE DIFFERENT DATES IN 1949

Harvesting date 1949	DDT treated		Check	
	Per cent disease 1950	Average $\sin^{-1}\sqrt{p}$	Per cent disease 1950	$\sin^{-1}\sqrt{p}$
August 22	15.8	22.5*	11.2	17.7*
September 12	15.0	22.0	14.2	20.9
October 3	13.2	20.9	16.5	23.4

* Significance: 5 per cent, 5.4; 1 per cent, 7.4.

TABLE 3.—*Experiment II:* RELATIVE POSITION OF PLOTS IN 6 × 6 LATIN SQUARE; HARVESTING DATE AND NUMBER OF PLANTS INFECTED WITH POTATO VIRUS Y IN EACH PLOT

*S 7	*2*	A31	*18*	S14	*14*	A24	*3*	A17	6	A10	*7*
S14	*14*	S 7	*10*	A24	*18*	A17	*13*	A10	*9*	A31	*5*
*A17	*8*	A10	*3*	S 7	*13*	S14	*9*	A31	*24*	A24	*13*
A31	*13*	A24	*1*	A17	*8*	A10	*4*	S14	*26*	S 7	*15*
A10	*5*	S14	*8*	A31	*24*	S 7	*31*	A24	*12*	A17	*18*
A24	*10*	A17	*5*	A10	*14*	A31	*8*	S 7	*22*	S14	*15*

* S: September; A: August.

A sample of 100 tubers was saved from each plot at the time of harvesting in each of the above three experiments. These tubers were planted out of doors the following year, and the percentage of infection by virus Y which had occurred the previous year was determined from the number of infected plants (expressed as rugose mosaic) growing from these tubers.

The results obtained from each of the experiments were in the form of discrete data, based upon a number of trials. This necessitated the use of the angular conversion method in the analysis of variance. The differences required for significance which are supplied with Tables 2, 4, and 6 should be used solely for the comparison of converted data expressed as $\sin^{-1}\sqrt{p}$ (where p = percentage of disease, as explained by Clark and Leonard (4), Cochran (5), and Leonard and Clark (11)).

RESULTS OF EXPERIMENTS

Experiment I

This experiment was intended to evaluate the effect of aphid control with DDT and of harvesting potatoes on three different dates, upon the spread of virus Y. The results are shown in Table 1, and summarized in Table 2.

The spread of virus Y (expressed as rugose mosaic in the succeeding crop) in the series of check plots harvested on August 22 was significantly less than that which occurred in the series of check plots harvested on October 3. Other than this specific difference, no other difference between any two series of plots in this experiment was significant.

Experiment II

This experiment was conducted to determine the period during which the greatest spread of potato virus Y occurred. Plots in this experiment were harvested on six different dates instead of three, as in Experiment I. The results are given in Table 3, and summarized in Table 4.

These results show that the samples harvested on August 10 contained significantly less disease than those harvested on August 31, and September 14. No other difference was significant.

TABLE 4.—*Experiment II:* PERCENTAGE OF RUGOSE MOSAIC IN PLOTS HARVESTED ON SIX DIFFERENT DATES IN 1949

Harvesting date 1949	Per cent disease 1950	Average $\sin^{-1}\sqrt{p}$
August 10	7.0	14.9*
August 17	9.7	17.7
August 24	9.5	16.8
August 31	15.3	22.4
September 7	15.7	22.0
September 14	14.3	22.3

* *Significance:* 5 per cent, 7.2; 1 per cent, 9.8.

TABLE 5.—*Experiment III:* RELATIVE POSITIONS OF PLOTS IN THE FOUR 6 × 6 LATIN SQUARES; HARVESTING DATE AND NUMBER OF PLANTS INFECTED WITH POTATO VIRUS Y IN EACH PLOT

Block 1 (Check)

S14	*32*	A17	*20*	A10	*14*	S 7	*22*	A31	*40*	A24	*31*
A17	*24*	A24	*28*	S 7	*27*	S14	*44*	A10	*14*	A31	*29*
S	*24*	A31	*30*	A17	*14*	A24	*27*	S14	*31*	A10	*23*
A31	*42*	S 7	*35*	S14	*17*	A10	*21*	A24	*45*	A17	*42*
A24	*19*	A10	*12*	A31	*28*	A17	*36*	S 7	*49*	S14	*34*
A10	*12*	S14	*42*	A24	*23*	A31	*22*	A17	*29*	S 7	*30*

Block 2 (DDT)

A31	*24*	A10	*18*	A24	*25*	A17	*19*	S 7	*29*	S14	*46*
A24	*20*	A31	*21*	S14	*31*	S 7	*27*	A17	*21*	A10	*14*
S14	*39*	S 7	*35*	A31	*24*	A24	*21*	A10	*14*	A17	*14*
A17	*15*	A24	*17*	S 7	*31*	A10	*18*	S14	*27*	A31	*22*
A10	*16*	S14	*31*	A17	*23*	A31	*18*	A24	*25*	S 7	*22*
S 7	*37*	A17	*19*	A10	*12*	S14	*30*	A31	*18*	A24	*30*

Block 3 (DDT)

S14	*31*	A24	*25*	A31	*40*	A17	*33*	A10	*32*	S 7	*41*
A31	*40*	S 7	*30*	A17	*34*	A10	*27*	A24	*35*	S14	*40*
A24	*29*	A10	*21*	S 7	*27*	S14	*28*	A17	*27*	A31	*41*
A10	*15*	S14	*35*	A24	*29*	S 7	*39*	A31	*31*	A17	*33*
S 7	*29*	A17	*16*	A10	*31*	A31	*37*	S14	*31*	A24	*30*
A17	*21*	A31	*25*	S14	*31*	A24	*26*	S 7	*35*	A10	*34*

Block 4 (Check)

A10	*15*	S 7	*20*	S14	*25*	A31	*26*	A17	*21*	A24	*23*
A24	*30*	A10	*19*	A31	*11*	S 7	*15*	S14	*41*	A17	*25*
A17	*19*	A31	*18*	A24	*28*	A10	*18*	S 7	*38*	S14	*36*
S14	*23*	A17	*24*	S 7	*29*	A24	*25*	A31	*28*	A10	*25*
S 7	*27*	A24	*16*	A17	*12*	S14	*22*	A10	*17*	A31	*33*
A31	*21*	S14	*28*	A10	*16*	A17	*33*	A24	*26*	S 7	*26*

Experiment III

This experiment combined the date of harvesting and aphid control with DDT, in relation to the spread of potato virus Y, of Experiments I and II, but on a larger scale. Results are given in Table 5, and summarized in Table 6. An outline of the statistical analysis is shown in Table 7.

In this experiment, no significant difference was found when the amount of rugose mosaic disease in the samples from DDT-treated plots harvested on any given date was compared with the disease in the samples from the check plots harvested on the same date.

There was a direct relation between the date of harvesting the tubers and the amount of disease in the sample. By August 10, 19.1 per cent of the tubers, judging from the number of diseased plants growing from these the following year, had become infected with virus Y. The differences between the percentage of infection in the samples harvested on August 10 and those of the samples harvested on subsequent dates are all highly significant.

By August 17, 23.9 per cent of the sample tubers were infected with virus Y. This percentage was less than that found in the samples harvested on August 31 or later. The difference between the percentage of infection in the samples harvested on August 17 and that of the samples harvested on August 31 was significant, while that between the former and those harvested on September 7 and 14 was highly so. The sample tubers harvested on August 24 were 26.4 per cent infected. This was significantly less than the percentage of infection which had occurred by September 7, while the difference between the former and the percentage of infection in the sample harvested on September 14 was highly significant.

TABLE 6.—*Experiment III:* PERCENTAGE OF RUGOSE MOSAIC IN SAMPLES FROM DDT-SPRAYED PLOTS AND CHECK PLOTS HARVESTED ON SIX DIFFERENT DATES IN 1950

Harvesting date 1950	Blocks 2 and 3 (DDT treated)		Blocks 1 and 4 (check)		DDT and check (combined)	
	Per cent disease 1951	Average $\sin^{-1}\sqrt{p}$	Per cent disease 1951	Average $\sin^{-1}\sqrt{p}$	Per cent disease 1951	Average $\sin^{-1}\sqrt{p}$
August 10	21.0	27.0*	17.2	24.4*	19.1	25.7**
August 17	22.9	28.4	24.9	29.6	23.9	29.0
August 24	26.0	30.6	26.7	31.0	26.4	30.8
August 31	28.6	32.0	27.3	31.2	27.9	31.6
September 7	31.8	34.3	28.5	32.0	30.2	33.2
September 14	33.3	35.2	31.2	33.8	32.3	34.5

Significance:
* Between DDT treatments and checks of comparable harvesting dates: 5 per cent, 3.2; 1 per cent, 4.2.
** Between different harvesting dates: 5 per cent, 2.3; 1 per cent, 3.0.

TABLE 7.—ANALYSIS OF *Experiment III*, THE INDIVIDUAL PERCENTAGES HAVING FIRST BEEN CONVERTED TO $\text{SIN}^{-1}\sqrt{\text{P}}$

	S. S. Block 1	S. S. Block 2	S. S. Block 3	S. S. Block 4	S. S. Total	D. F.
Dates	545.5	677.7	160.5	182.7	1566.4	20
Columns	297.3	16.0	188.6	176.8	678.7	20
Ranges	113.7	43.5	77.2	63.9	298.3	20
Error	514.6	208.8	174.0	376.4	1273.8	80
	1471.1	946.0	600.3	799.8	3817.2	140

Error variance: 15.92

S. E. of mean 24: $\sqrt{\frac{15.92}{24}}$

S. E. of difference between two such means: $\sqrt{\frac{15.92 \times 2}{24}} = 1.15$

Difference required for significance: (Fisher's "*t*" test)

5 per cent: $1.15 \times 1.96 = 2.25$

1 per cent: $1.15 \times 2.58 = 2.97$

NOTE: In comparison of DDT (Blocks 2 and 3) vs. Check (Blocks 1 and 4), it is necessary to calculate the variance of each of the two groups separately before obtaining the standard error of difference between two means derived from the two different groups. The analysis then proceeds:

	DDT (Blocks 2 and 3)	Check (Blocks 1 and 4)
Error variance:	9.57	22.27
S. E. of mean of 12:	$\sqrt{\frac{9.57}{12}}$	$\sqrt{\frac{22.27}{12}}$

S. E. of difference between two means: $\sqrt{\frac{9.57 + 22.27}{12}} = 1.63$

Difference required for significance:

5 per cent: $1.63 \times 1.96 = 3.19$

1 per cent: $1.63 \times 2.58 = 4.21$

The amount of disease had increased to 27.9 per cent by the time samplings were made on August 31, significantly less than that of the samples obtained on September 14. The disease present in the September 7 samples was 30.2 per cent and in the September 14 samples, 32.3 per cent. These latter two percentages were not significantly different from each other.

APHID POPULATION

The relative abundance of aphids in the DDT-treated plots and the check plots of Experiments I and III, based on counts made during 1949 and 1950, are given in Table 8.

TABLE 8.—RELATIVE APHID POPULATIONS IN THE PLOTS RECEIVING DDT INSECTICIDE AND IN THE CHECK PLOTS OF GREEN MOUNTAIN POTATOES GROWN IN 1949 AND IN 1950

	Aphids per hundred leaves*			
	Experiment I, 1949		*Experiment III*, 1950	
	DDT	Check	DDT	Check
July 26	2	9	3	15
August 2	34	54	9	125
August 9	130	607	35	305
August 16	98	635	42	425
August 23	65	1068	56	706
August 30	106	1222	86	3000
September 6	148	1486	85	2100
September 13	132	1380	74	1410

* Each figure is based on a sample of 600 whole leaves picked alternatively from upper, middle, and lower parts of different plants.

The counts of the relative aphid populations were not intended for statistical analysis. The earliest date in both years on which aphids were found was July 26. It is clear that a seasonal build-up of the aphid population towards a maximum in late August or early September occurred during both 1949 and 1950, and also that DDT exercised a considerable control of these insects, although an incomplete one.

DISCUSSION

In Experiment I, the application of DDT insecticide, despite its resultant decrease in the aphid population, apparently failed to prevent the spread of virus Y during 1949.

The results of Experiment II, conducted in 1949, show that nearly half of the eventual spread of virus Y had occurred by August 10, and that a gradual spread continued thereafter. This trend was confirmed and strongly emphasized by the results of Experiment III, conducted in 1950, which was carried out on a larger scale. Approximately 60 per cent of the

eventual disease level had been reached by August 10 during 1950. Thereafter, a small additional increase had occurred by each succeeding harvesting date.

Despite the fact that DDT insecticide exercised a considerable control of the aphid population in the sprayed plots of Experiment III, there was no statistically significant difference in the disease level between the DDT-sprayed and the check plots at any time from August 10 to September 14 in 1950. The fact that a lowered aphid population was as effective in spreading virus Y as a larger one confirms the findings of Kotila (10) and Doncaster and Gregory (8).

These experiments show that a high percentage of tuber infection with virus Y had occurred as early as August 10 in both 1949 and 1950. The actual inoculation of the plants, following which the virus had reached the tubers by this date, must have occurred somewhat earlier when aphid populations were at a comparatively low level. Doncaster and Gregory (10) also found that most infections with virus Y had occurred well before maximum aphid populations had been reached. This suggests an interesting connection between Davies' (7) observation of early season migrants of the aphid *Myzus persicae* Sulz. taking to wing after having deposited a solitary nymph and the finding by Bradley and Rideout (3) that this species, and others infesting potatoes in Eastern Canada, can transmit virus Y following brief feeding periods upon infected plants.

Experiments conducted by the author during 1947 and 1948 without the inclusion of rows of plants infected with virus Y, but depending upon a small percentage of infected seed for local source of this virus, resulted in relatively small percentages of new infection. Also, plots of seed potatoes have been maintained almost free from virus Y for a number of years, within one thousand feet of the otherwise isolated site of these experiments. This would preclude the possibility that any large amount of infection could have been caused by viruliferous aphids from more distant outside sources, and agrees with the report of Conners and Savile (6) that the spread of mosaic depends largely upon the initial infection of the seed.

Available evidence suggests that the activity of the aphids within the field, and probably also the species present, at different periods of the growing season, would be of more importance than the total number of aphids.

The present results indicate that early harvesting would not be an economical method of controlling potato virus Y in the Fredericton district because of the great amount of spread which occurs so early in the season. The need for early and thorough roguing is emphasized and the removal of plants surrounding a diseased unit is suggested where the production of healthy seed is the prime objective.

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EVIDENCE FOR POLYGENESIS IN SOILS OF THE OSPREY SERIES

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ABSTRACT

Three virgin profiles of Osprey soils have been examined morphologically and samples from the major horizons subjected to physical and chemical analysis. The results obtained suggest that soils of the Osprey series should be considered to be Brown Forest Grey-Brown Podzolic Intergrades.

The Osprey soils occur in Grey and Bruce Counties in the Province of Ontario, Canada. They have developed from highly calcareous materials deposited at the time of the last Wisconsin glaciation. They are strongly influenced by Bertie-Akron dolomitic limestone ground by the ice into flour or left throughout the matrix as rock fragments. The latter, still found in the weathered part of the profile, continue slowly to release bases and maintain a high base status in the upper soil horizons.

The Osprey materials were deposited mostly as a terminal moraine, the topography being irregular, moderate to very steeply sloping. Because of the large amount of surface run-off coupled with moderate internal drainage these soils are well drained to excessively drained.

The Osprey soils developed under hardwood vegetation of the maple, beach association (2). The vegetation in existing woodlots consists of maple, beech, basswood, ash, white birch, butternut, hemlock and the occasional pine.

The climate of Grey County can be summarized and compared with the climate of other areas by making use of the Thornthwaite formula, as adapted to Canadian conditions by Sanderson (7).

Table 1 provides such data for the Grey County area, the Guelph area, which is well within the Grey-Brown Podzolic Zone, and Peterboro and Eastern Ontario, where Brown Forest Soils are mapped.

It would seem from the climatic data as shown in Table 1 that differences in the Zonal profile cannot be attributed wholly to climate.

Table 1

Location	Water need	Actual water used	Water deficiency	P.E. index
	inches	inches	inches	
Grey County	22.0	20.4	1.6	69.0
Peterboro	23.2	20.6	2.6	41.0
Eastern Ontario	23.5	19.5	4.0	23.2
Guelph	22.9	20.9	2.0	31.3

TABLE 2.—SUMMARY OF MORPHOLOGICAL CHARACTERISTICS OF THE THREE OSPREY PROFILES

Series	Horizon	Depth, inches	Texture	Structure	Consistency	Colour	Colour code*	pH	Stoniness
Osprey 1A	A_1	3	Si. l.	Crumb	Very friable	Black	2.5YR2/0	6.5	Few stones
	B_1	2	L.	Very weak nuciform	Very friable	Brown	7.5YR4/2	6.8	Few stones
	B_2	2	C. l.	Weak nuciform	Friable	Dark brown	7.5YR3/2	7.5	Numerous small stones
	B_3	4	L.	Nuciform	Very friable	Brown	7.5YR5/4	8.0	Stony
	C	—	L.	—	—	Light yellowish brown	10 YR6/4	8.3	Very stony
Osprey 1B	A_1	3	Si. l.	Crumb	Very friable	Black	2.5YR2/0	7.1	Few stones
	B_1	5	Si. l.	Very weak nuciform	Very friable	Dark brown	7.5YR3/2	7.0	Few stones
	B_2	4	C. l.	Weak nuciform	Friable	Dark reddish brown	5 YR3/3	7.2	Few stones
	B_3	3	C. l.	Weak nuciform	Friable	Dark reddish brown	5 YR3/2	7.5	Numerous small stones
	C	—	L.	—	—	Light yellowish brown	10 YR6/4	8.3	Very stony
Osprey 2A	A_1	3	Si. l.	Crumb	Very friable	Black	2.5YR2/0	6.7	Few stones
	B_1	3	L.	Very weak nuciform	Very friable	Very dark grey brown	10 YR3/2	6.9	Few stones
	B_2	2	C. l.	Weak nuciform	Friable	Dark brown	7.5YR3/2	7.4	Numerous small stones
	C	—	S. l.	—	—	Light yellowish brown	10 YR6/4	8.1	Very stony

* According to *Munsell Colour Standard.*

The morphological characteristics of the three Osprey profiles used in this study are given in Table 2. The profile characteristics differ from the Grey-Brown Podzolic Soils as follows:

1. The horizon of eluviation is absent or poorly defined.
2. The solum is thin (7-18 inches) in comparison with the Grey-Brown Podzolic soils (24-36 inches).
3. Under virgin conditions the pH of the solum is higher than usually found in the Grey-Brown Podzolic group.
4. Translocation of sesquioxides is less well defined than in Grey-Brown Podzolic soils.
5. Aggregation in the B horizon is less well developed.
6. There is a predominance of brown colour throughout the solum which is not characteristic of Grey-Brown Podzolic soils.

The lack of a well defined horizon of eluviation, the shallow solum, the high pH, and the brown colour are all characteristics associated with Brown Forest Soils.

Experimental Methods

Large L-shaped trenches were dug at each location and the samples were taken from a location in the trench representing average conditions. The samples from each layer were procured from the central zone of the horizon, eliminating the transitional portions of each horizon. The chemical data published herewith represent the maximum development in each layer.

The soil samples were air-dried, and put through a 1-mm. sieve. After very thorough mixing, representative samples from the main soil samples for each horizon were taken and stored in labelled moisture cans.

The method of Bouyoucos was followed for the mechanical analysis of the soil samples. The glass electrode was used for the determination of soil reaction. Soil samples were saturated with water for this determination.

The chemical methods of total analyses were those adapted from Hillebrand and Lundell (3). Platinum crucibles were used for all combustion procedures.

The method for the determination of organic carbon was the potassium dichromate method as described by Walkley (9).

EXPERIMENTAL RESULTS AND DISCUSSION

Reaction

The pH of the successive horizons of each Osprey profile is shown in Figure 1. The soil pH increases progressively from the surface horizon to the parent materials with the possible exception of 1B. In this profile the pH dropped from 7.1 in the A_1 to 7.0 in the B_1 horizon. The reaction throughout the solum of the Osprey profiles is comparable to that described by McCaleb and Cline (6) for the Brown Forest soils of New York and to that of the Grenville profile described by Stobbe* as a Brown Forest soil in Eastern Ontario.

*Stobbe, P. C. Comparative study of the Grey-Brown Podzolic, and Brown Forest Soils of Southern Ontario, and Southern Quebec. *Unpublished Ph.D. thesis*, University of Montreal. 1950.

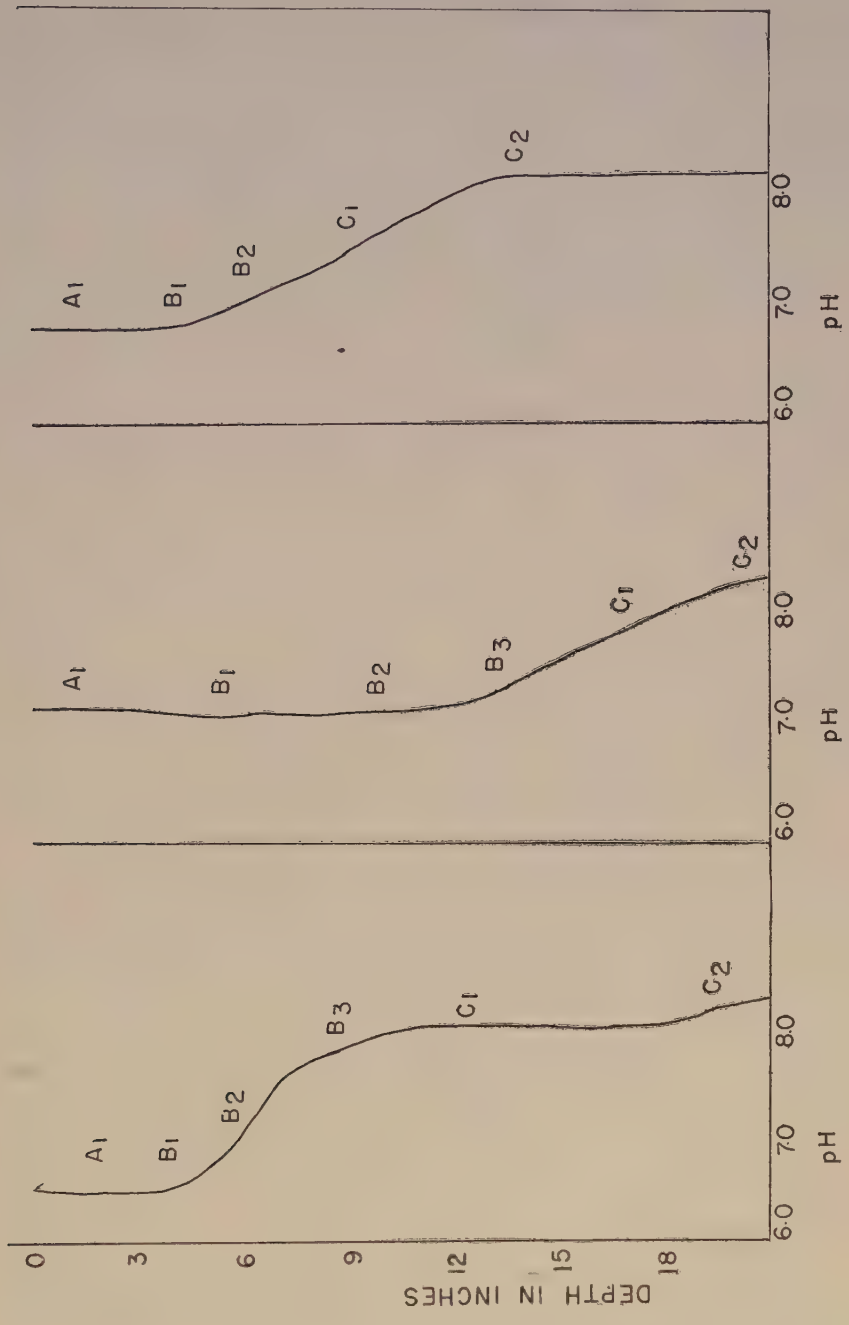

FIGURE 1. Soil reaction in the three Osprey profiles.

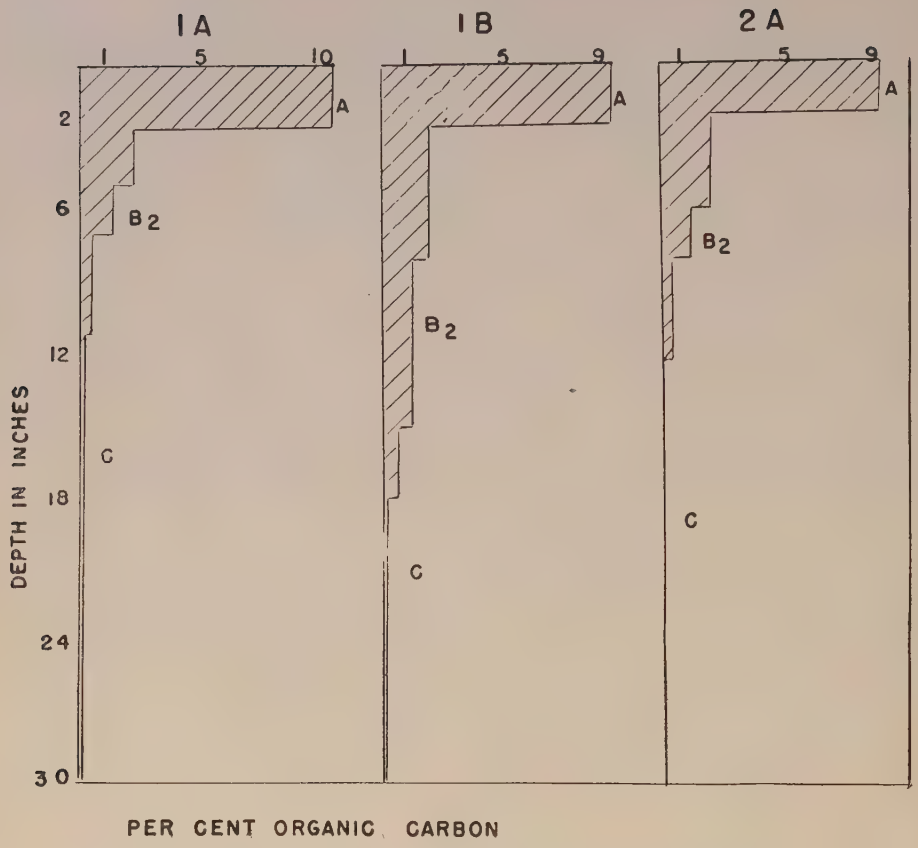

FIGURE 2. Distribution of organic carbon in the Osprey profiles.

Organic Carbon

Figure 2 indicates that the percentage of organic carbon decreases with depth in each Osprey profile—a feature considered typical of Brown Forest soils. Grey-Brown soils as shown by Stobbe* have an accumulation of organic material in the B_2 horizon.

The percentage of organic carbon in the A_1 horizon is unusually high for typical Grey-Brown Podzolic soils. The average thickness of this horizon is slightly over three inches and would appear to be somewhat thinner than the A_1 horizons of modal Brown Forest soils. This would suggest that the Osprey profiles are neither modal Grey-Brown Podzolic nor modal Brown Forest in character.

Silica

The distribution of silica in the three profiles is shown in Figure 3. The increase of silica in the B_1 horizons of each profile in respect to the A_1 horizon, with a corresponding decrease of silica in the B_2 horizons, is an indication of removal of some constituents from the B_1 horizons and accumulation in the B_2 horizons.

*Stobbe, P. C. Comparative study of the Grey-Brown Podzolic, and Brown Forest Soils of Southern Ontario, and Southern Quebec. *Unpublished Ph.D. thesis*, University of Montreal. 1950.

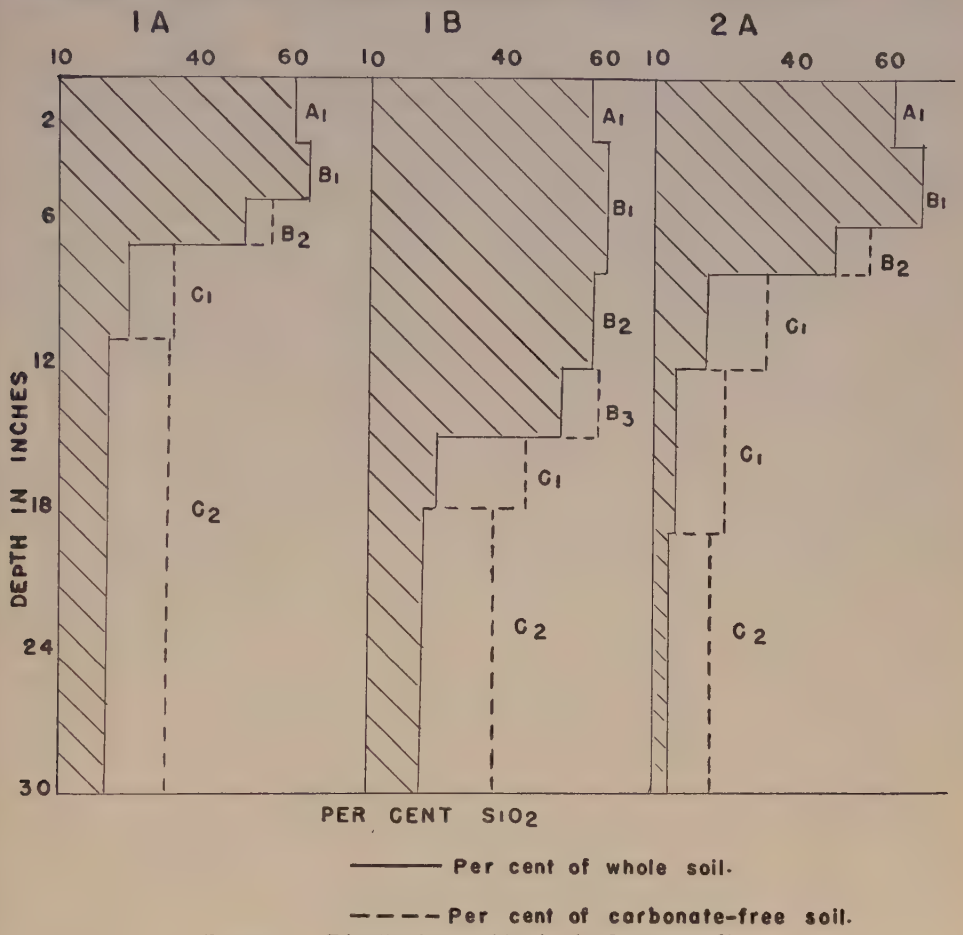

FIGURE 3. Distribution of silica in the Osprey profiles.

Iron

The distribution of iron throughout the profiles is shown in Figure 4. There has been a significant increase in iron in the B_2 horizon of each profile. The B_2 horizon, however, is thin so that the total movement of iron is small relative to that in typical Grey-Brown Podzolic Profiles on similar materials. The data of McCaleb and Cline (6) showing the movement of iron in the Brown Forest Intergrade soils in New York State would indicate a greater movement of iron in those soils than in the Osprey soils.

Silica-Alumina Molecular Ratio

The silica-alumina molecular ratios for the three Osprey profiles are shown in Figure 5. They indicate an accumulation of alumina in the B horizons of each profile and also show considerable accumulation of alumina in the C_1 horizons of profiles 1A and 1B. Profile 2A shows the least movement and represents in this respect the nearest approach to a Brown Forest type of development in the three profiles. McCaleb and Cline (6) published similar ratios for the Brown Forest Grey-Brown Podzolic Intergrade soils of New York State. The ratios for the Osprey profiles compared favourably in respect to movement of alumina with those for the New York soils.

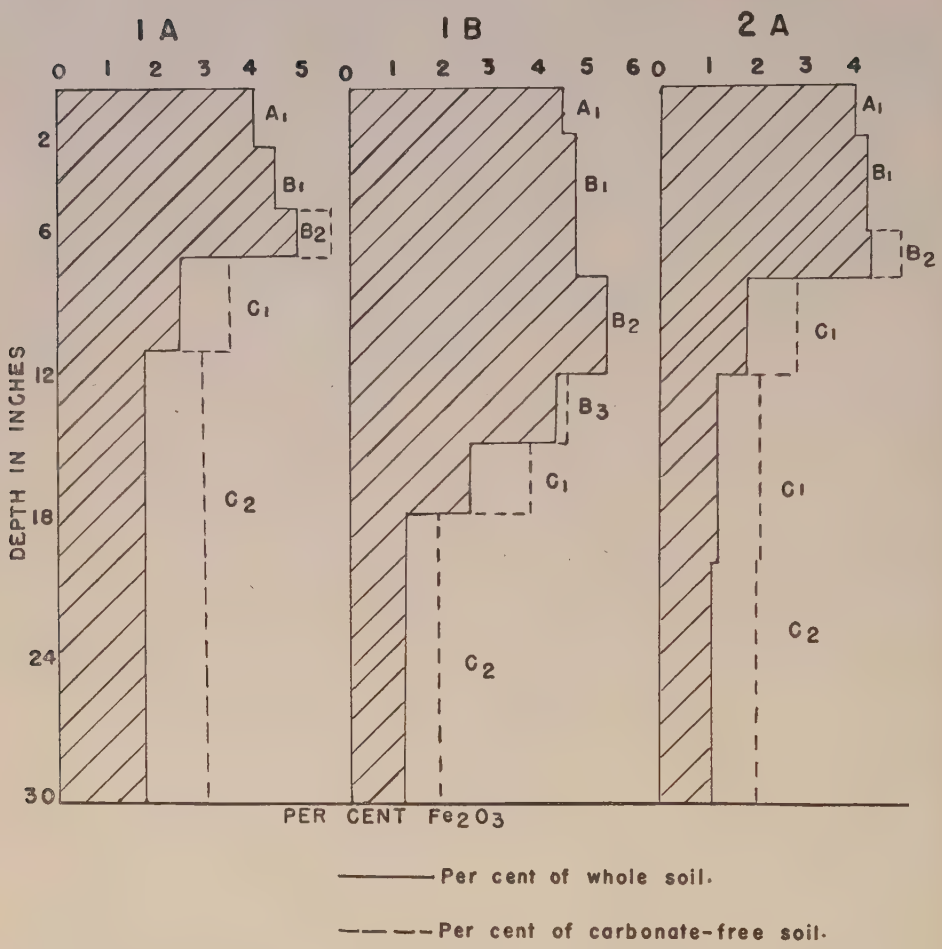

FIGURE 4. Distribution of iron in the Osprey profiles.

CaO + MgO — Al_2O_3 Molecular Ratio

The molecular ratios of the sum of the divalent cations to alumina are shown in Figure 6. They show the tremendous amount of weathering of these bases from the surface layers. The removal of such large amounts of calcium and magnesium from the surface horizons has increased the percentage composition of clay and other resistant minerals. The data for silica, iron and alumina also reveal the increased percentage of these minerals in all horizons from which large quantities of carbonates have been removed.

The shallow layer from which carbonates have been removed would suggest that these high lime soil materials have resisted the weathering processes and, as the removal of calcium and magnesium continues, the solum should gradually increase in depth.

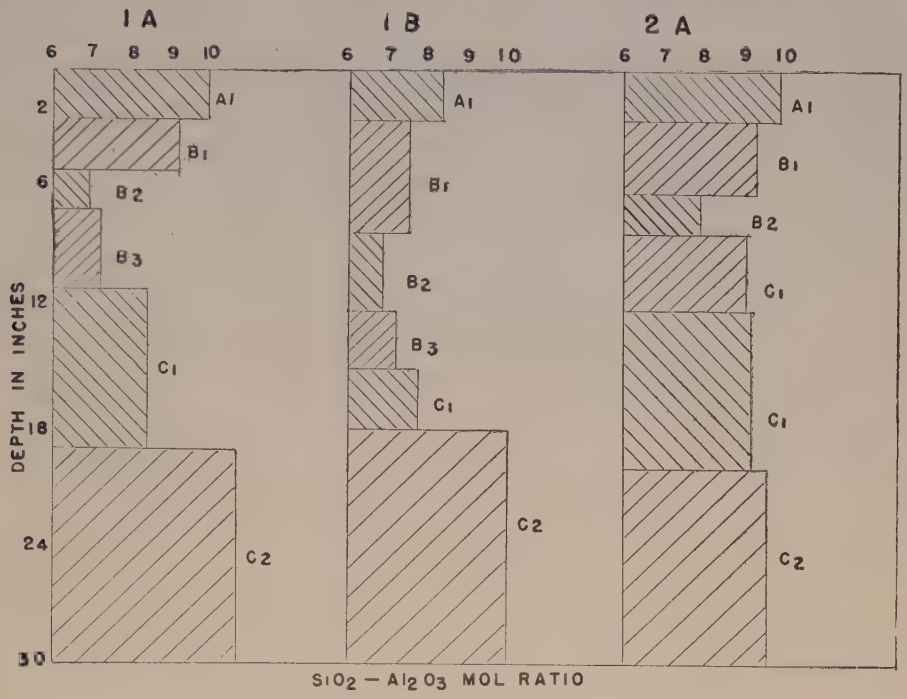

FIGURE 5. Silica-alumina molecular ratios.

Clay Distribution

The distribution of fine clay (2μ) is shown in Figure 7. The dotted lines on the diagram are for the clay calculated on a carbonate-free basis. The graphs portray the accumulation of clay in the B_1 and B_2 horizon of each profile with the maximum accumulation in the B_2 horizon. The clay accumulation in the solum is the result of two processes. The first is the loss of the divalent bases with the resultant shrinkage of the solum increasing the concentration of clay minerals in the weathered surface. The second process is the weathering of primary minerals into more stable silicate clays.

In the three Osprey profiles, the clay content of the B_1 horizon is as high as, or slightly higher than that in the parent material. This does not preclude the possibility that some clay has migrated from this horizon. The "telescoping effect" of the surface soil because of the removal of carbonates should result in an increase in clay content above that of the parent material. As this increase is very small, it is indeed likely that some clay has moved downward from the surface horizon.

The increase in the clay content of the B_2 horizon in the Osprey profiles is not characteristic of the modal Brown Forest Soils.

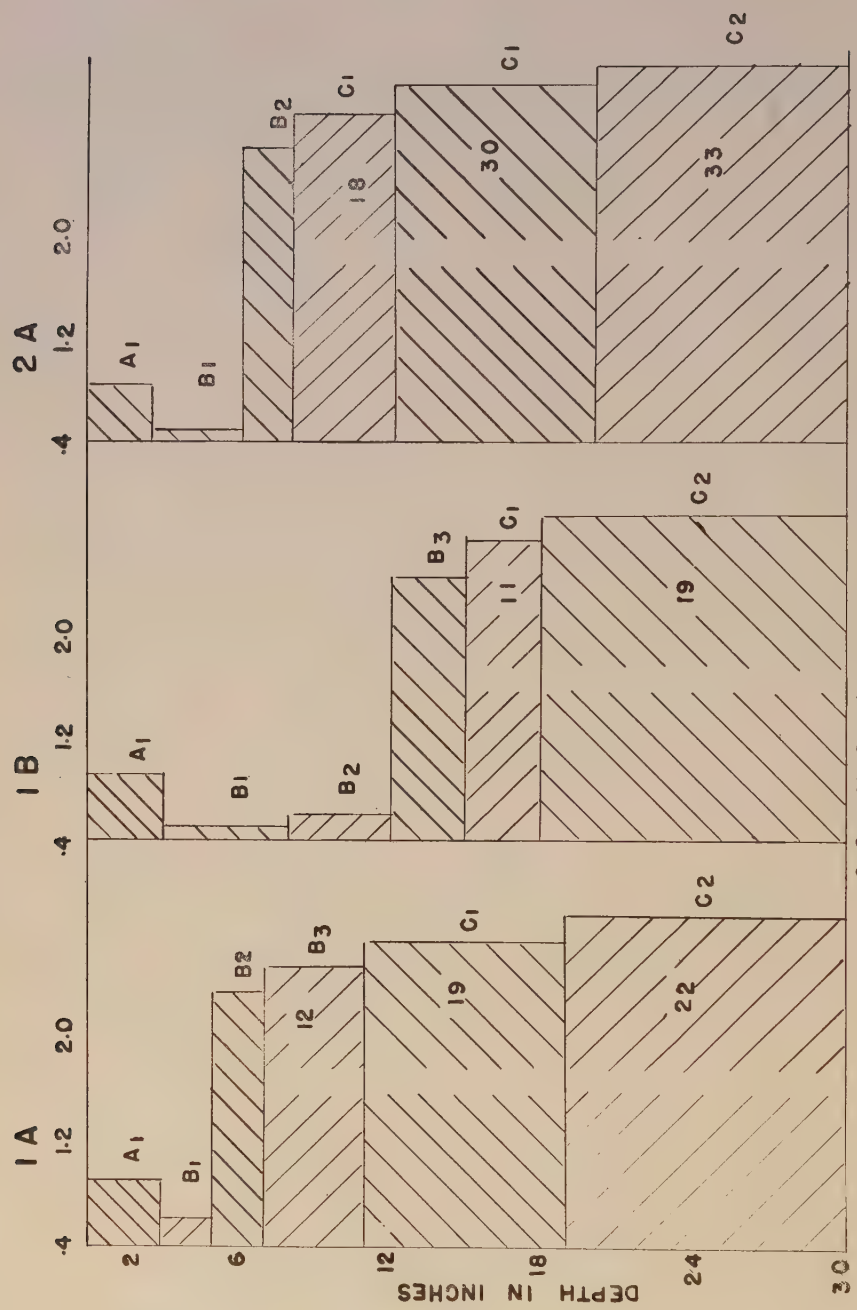

FIGURE 6. Molecular ratios of the sum of the divalent cations to alumina.

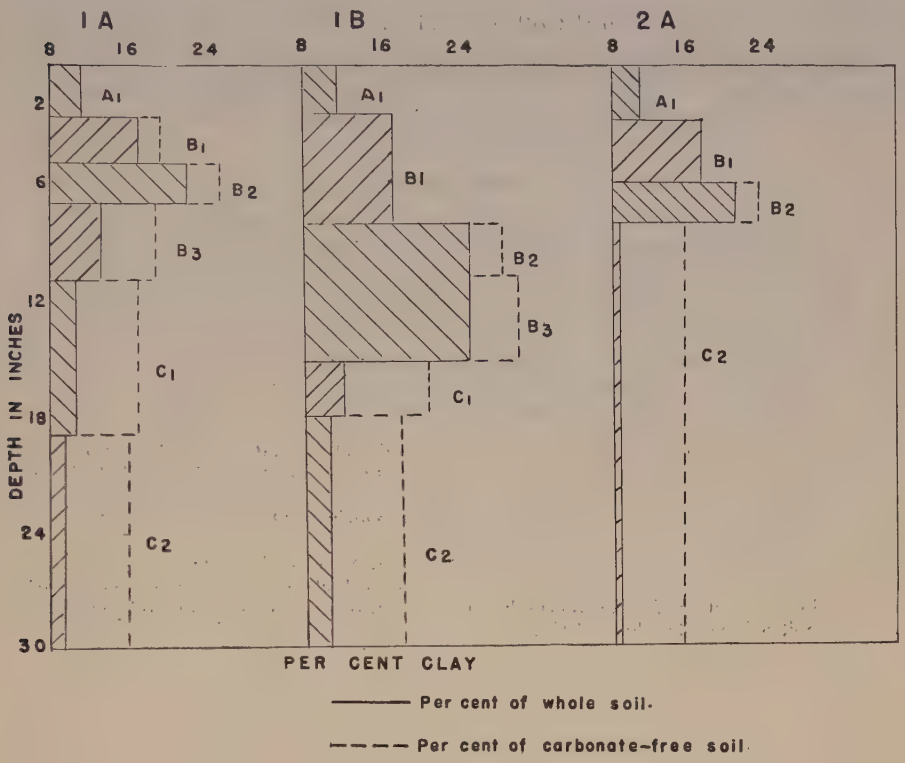

FIGURE 7. Distribution of the 0.002 mm. clay in the three Osprey profiles.

SUMMARY

Morphological field studies, in addition to particle size distribution, pH, organic carbon, and the chemical composition by the method of sodium carbonate fusion for silica, iron, alumina, phosphorus, titanium, calcium and magnesium were determined for the genetic horizons of three Osprey profiles.

The morphological characteristics of these soils resemble those of the Brown Forest soils with the exception of the textural B_2 horizon exhibited in the Osprey profiles.

The chemical data indicate that there has been some accumulation of sesquioxides in the B_2 horizons of these profiles which is evidence that the Podzolization process is active. However, since it is evident that Podzolization is in an early stage and the profiles exhibit many of the characteristics of the Brown Forest soils, the Osprey series is best correlated as a Brown Forest Grey-Brown Podzolic Intergrade.

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SOME OBSERVATIONS ON THE EFFECTS OF WEATHER ON THE UTILIZATION OF SUPERPHOSPHATE AND MANURE APPLIED AS A TOP-DRESSING TO A PERMANENT PASTURE[1]

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ABSTRACT

Top-dressing of a permanent pasture on Rideau clay was made to compare the top-dressing with superphosphate applied in the spring with manure and/or superphosphate applied in the fall. The data from the yield of dry matter and the phosphorus content were analysed statistically for each of five dates of clipping and between dates. This evaluation showed yield differences between dates of clipping but not for treatments. The phosphorus content was increased more effectively by manure applied in the fall or superphosphate applied in the spring than by superphosphate applied in the fall. Superimposing of one top-dressing on another was without effect on the yield or phosphorus content of the herbage. The rainfall pattern for the season was such that both yield and phosphorus content were greater in May and September. These studies were supplemented by an experiment conducted in the greenhouse during the winter using cylinders of the sward cut to the depth of the pot and fertilization with phosphate and manure. Chemical analysis of the soil from the pasture was made at inch intervals which showed high levels of the exchangeable cations.

INTRODUCTION

In Eastern Canada, many pastures are located on rough or otherwise unused portions of the farm. These pastures, for the most part, are not fertilized other than by the manure from the grazing animals, and those pastures that receive mineral fertilizer are usually given a top-dressing in the fall. In general, a longer period exists at that time for such fertilization than in the spring. Many pastures in Quebec are found along the banks of rivers or gullies in the St. Lawrence lowland plain and the soil is often Rideau clay. The site for the present studies is on this soil type at Macdonald College, in an area of permanent pasture. The sward was composed of Kentucky blue grass, wild white clover with some dandelion and lesser amounts of other grasses and weeds.

The treatments used in these studies were chosen to represent top-dressing with ten tons of manure in the fall, with 400 pounds of superphosphate in the fall and with 400 pounds of superphosphate in the spring. A previous study in the same general area using labelled superphosphate (6) showed that most of the phosphate of the fertilizer remained in the first layer-inch of this soil and that a considerable proportion of the phosphorus in the clippings was derived from the fertilizers, particularly after light rains following a dry period. In the present studies larger plots were used and harvesting of the sward was conducted as clippings at five dates from May to September. The dry weights and phosphorus content were obtained for these samples and statistical evaluation for treatments and dates of clipping applied to such data.

[1] Contribution from the Faculty of Agriculture, McGill University, Macdonald College, Quebec, Canada. Journal Series No. 322.

[2] Formerly graduate student in the Department of Chemistry, Macdonald College; now assistant biochemist, Department of Soils, Agricultural Experiment Station, University of Florida, Gainesville, Fla.

[3] Professor of Agronomy.

[4] Associate Professor of Agronomy.

[5] Associate Professor of Agricultural Chemistry.

REVIEW OF LITERATURE

Many workers have made studies with respect to pasture improvement from the application of phosphatic fertilizer. Audidier and co-workers (2), Brown (3), Cottenie (4), Midgley (12) and Sherwood *et al.* (15) reported under widely different conditions that the phosphorus content of the herbage showed response to phosphatic fertilizer applied alone but yield response could be expected more often when a mixed fertilizer was applied. Weir (20) noted that the yield and quality of several pastures in Ontario were improved by top-dressing with manure and 4-12-6 fertilizer mixture. Swift *et al.* (19) reported that the monthly yields and composition of the herbage from a lawn of *Trifolium repens* and *Poa pratensis* varied from month to month with the weather being a major factor as well as the composition of the fertilizer that was applied.

The penetration of phosphatic fertilizer applied as a top-dressing has been studied by Midgley (12) and Weiser (21) in Vermont and from their experiments it was pointed out that the shallowness of the penetration was such that the zone of root activity might not be reached, resulting in the phosphorus content of the herbage being ineffectively increased. Other studies reported by Eby *et al.* (5), Goldschmidt (8), Sell and Olsen (14), Heck (9), MacIntire and co-workers (11), Neller (13), Spencer and Stewart (16) and Stephenson and Chapman (18), for other soils, showed that yield responses were obtained from top-dressing with phosphatic fertilizer when appreciable penetration occurred, the latter being measured by solubility tests. Stanford, McAuliffe and Bradfield (17) applied labelled superphosphate as a top-dressing to alfalfa, ladino clover and orchard grass and found that under conditions of semi-drought the roots of these plants obtained more of their requirements for phosphate from the fertilizer source than from sources in the soil.

Surface application of superphosphate to Quebec permanent pasture on a brown forest soil was studied by Wrenshall and McKibbin (22) and they reported yield responses attributable to the phosphate addition and also to sulphur but not to lime or potash cross dressings. Their work showed the shallow nature of the phosphate penetration although this

TABLE 1.—CHEMICAL ANALYSIS OF SOIL SAMPLES TAKEN AT DIFFERENT DEPTHS FROM THE PERMANENT PASTURE

Depth, inches	Acidity pH	Cation-exchange capacity me./100 gm.	Exchangeable cations per 100 gm. soil			
			C_a me.	M_g me.	K me.	H me.
0 to 1[1]	6.80	24.6	14.6	3.4	3.0	3.6
1 to 2	6.85	21.0	11.2	4.4	2.5	2.9
2 to 3	6.40	17.4	11.0	0.7	0.9	4.8
3 to 4	6.40	17.0	10.8	0.7	0.8	4.7
0 to 6[2]	5.8	—	10.0	3.5	0.5	—

[1] Samples taken November, 1948, after long period of dry weather.
[2] Average analysis of soil samples of Rideau clay reported by Lajoie and Stobbe (10).

FIGURE 1. Relationship of the yield of dry matter from the whole area sampled for each date of clipping to the rainfall and maximum temperature patterns.

phosphate was apparently available to the plants for three or four years. The plants on such permanent pasture removed more phosphorus than could be accounted for by the easily soluble phosphate in the soil as measured by chemical test.

EXPERIMENTAL EVIDENCE

Experimental Design

The experiment was laid out as a partially confounded $2 \times 2 \times 2$ design with four replicates and randomized treatments within the two sub-blocks of each replicate. Each plot was 5×16 feet with all plots making one continuous unit. The data were based on 54 square feet harvested from each plot, an 8-inch guard strip being made by a lawn-mower around the periphery before the removal of the central clippings. The treatments were eight in all, as follows:

(1)	(1)	**No treatment.**
(2)	**m**	Manure at the rate of 10 tons per acre top-dressed on November 30, 1948.
(3)	**pa**	Superphosphate, 400 lb. per acre, December 1, 1948.
(4)	**ps**	Superphosphate, 400 lb. per acre, April 23, 1949.
(5)	**mpa**	
(6)	**mps**	
(7)	**paps**	
(8)	**mpaps**	

The superphosphate (21 per cent total P_2O_5 analysis) was applied uniformly by hand. The cow manure which was well decomposed was distributed evenly by raking. The remnants from the manure were removed three days before the spring application of superphosphate. This precaution was deemed necessary to avoid contaminating the clippings. The field arrangement is shown in Table 3.

TABLE 2.—YIELD AND PHOSPHORUS CONTENT OF PASTURE HERBAGE IN GREENHOUSE STUDIES

Treatment	Without frost		With frost	
	Dry weight, gm.	Phosphorus content, mgm. P per 100 gm.	Dry weight, gm.	Phosphorus content, mgm. P per 100 gm.
Check (total)[1]	15.36	1677	12.09	1683
p (total)	16.35	2116	11.60	2558
pm (total)	18.53	2105	11.52	2145
pp_1 (total)	18.68	2344	12.83	2507
L.S.D. 5% level	0.65	408	1.68	289
L.S.D. 1% level	0.99	626	2.54	427

[1] Totals of values for four pots.

TABLE 3.—FIELD DESIGN, YIELDS PER PLOT AND AVERAGE PHOSPHORUS CONTENT OF CLIPPINGS FROM PERMANENT PASTURE, 1949

Replicate IV, m × pa × ps confounded			Replicate III, pa × ps confounded			Replicate II, ps × m confounded			Replicate I, pa × m confounded		
Treatment	Dry[1] weight, gm.	Content mgm. P/100 gm.	Treatment	Dry weight, gm.	Content mgm. P/100 gm.	Treatment	Dry weight, gm.	Content mgm. P/100 gm.	Treatment	Dry weight, gm.	Content mgm. P/100 gm.
mpaps	874	539	ps	922	460	mpa	1346	436	pa	1069	434
m	792	492	pa	734	424	paps	1142	422	mps	926	440
ps	732	499	mps	746	519	ps	642	465	m	804	420
pa	662	489	mps	961	512	m	663	481	paps	892	459
(1)	776	440	m	946	458	mpaps	831	499	(1)	897	366
paps	689	520	(1)	663	457	mps	1128	469	mpa	904	421
mpa	804	499	mpaps	723	523	(1)	776	320	ps	805	455
mps	1028	490	paps	861	473	pa	682	414	mpps	848	490

[1] Totals compiled from clippings taken on the five dates.

Analytical Procedures

The clippings were collected, placed in a paper bag, numbered, dried at 103° C. to constant weight and ground in a Wiley mill. Duplicate gram samples were weighed into tared crucibles and ashed in the oven using magnesium nitrate (1). The total phosphorus was determined using the molybdenum-blue modification of Gerritz (7).

The chemical analysis of the soil from the permanent pasture site was made at depths of one, two, three and four inches. The soil acidity was measured by glass electrode using a Model G Beckman pH meter. Base exchange capacity of the soil was determined by leaching with neutral ammonium acetate through 50 grams of sieved soil, subsequent removal of excess ammonium salt with several portions of 95 per cent ethanol, followed by distillation of the ammonia from the soil into standard acid. The filtrates from the leaching with the acetate were used for the determination of the exchangeable bases, the methods being those in routine use at the Division of Chemistry, Science Service, Central Experimental Farm, Ottawa. These results and those for Rideau clay described previously in the Soil Survey report by Lajoie and Stobbe (10) are shown in Table 1.

Dates of Clipping of Field Plots

The plots were mown when the sward was four inches or more in height. The first clippings were taken on May 7, with considerable variability in the growth of the sward being noted. At the time the next clippings were made, on May 25, the growth was greater and the variability less within the plots. The soil became much drier from the middle of May to late in June, the light growth resulting being shown by the weights of the clippings taken June 9. The plots were uniform in appearance at the time the clippings were taken on July 4 and the soil was moist at that time from the rains in late June. Further growth was not appreciable until late in August, a period of warm dry weather having produced near drought conditions in the interval. The final clippings, taken on September 22, showed the greatest growth for the season, the soil being well moistened by the heavy precipitation in late August. Further growth after this clipping was not appreciable and was not measured by additional clippings. The data from these clippings are combined in Table 3 and the statistical analysis of the data is shown in Table 4 for those cases where significance was found. These results are discussed below.

Greenhouse Studies

An experiment was conducted in the greenhouse during the winter using cylinders of soil and sward taken from the same area as the field experiment. These cylinders were cut to the internal measurements of 2-gallon pots and fitted tightly into each pot by gentle tapping. In this manner several dozen pots were prepared and of these 16 were selected at random and taken to the greenhouse without exposure to frost. Another set of 16 pots was exposed to two weeks of severe frost after fertilization.

TABLE 4.—STATISTICAL EVALUATION OF THE DATA FOR YIELD AND PHOSPHORUS CONTENT

Factor	Degrees of freedom	F value for phosphorus content						F value for dry matter*		Required F at p = 0.05
		Growing season	May 7	May 25	June 9	July 4	Sept. 22	Growing season	July 4	
Between fertilizers	31									
Blocks	7	3.96	(1)	1.73	7.64	2.08	1.87	(1)	2.39	2.62
Ps	1	15.86	5.29	1.86	13.11	7.82	9.51	(1)	4.10	4.45
Pa	1	4.70	(1)	1.16	17.00	3.10	(1)	(1)	(1)	4.45
M	1	13.56	(1)	6.64	34.84	15.54	1.45	2.06	4.66	4.45
M × Pa	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	4.45
M × Ps	1	(1)	(1)	1.53	(1)	(1)	(1)	(1)	(1)	4.45
Pa × Ps	1	(1)	(1)	(1)	2.51	(1)	(1)	(1)	1.23	4.45
M × Pa × Ps	1	2.43	(1)	(1)	(1)	3.59	5.68	3.57	3.96	4.45
Within fertilizers—										
D	4	8.77	—	—	—	—	—	256.3	—	2.46
D × M	4	5.39	—	—	—	—	—	2.40	—	2.46
D × Pa	4	1.69	—	—	—	—	—	(1)	—	2.46
D × Ps	4	4.63	—	—	—	—	—	(1)	—	2.46
D × M × Ps	4	(1)	—	—	—	—	—	(1)	—	2.46
D × M × Pa	4	(1)	—	—	—	—	—	(1)	—	2.46
D × Pa × Ps	4	(1)	—	—	—	—	—	1.00	—	2.46
D × M × Pa × Ps	4	(1)	—	—	—	—	—	4.89	—	2.46

* Dry matter did not show significance for any date other than July 4.
Note: (1) F values less than 1.

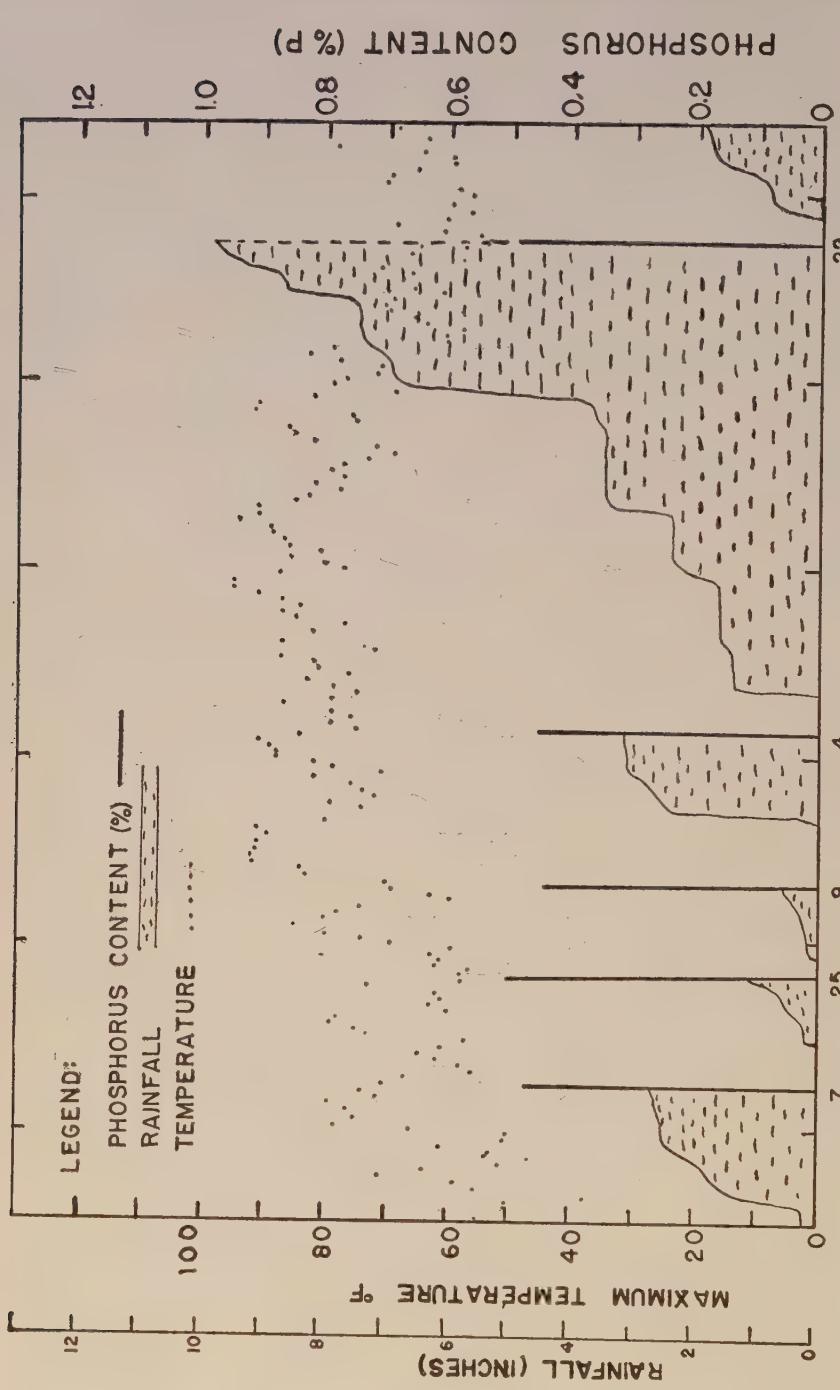

FIGURE 2. Relationship of the phosphorus content of the herbage as the average value for each date of clipping to the rainfall and maximum temperature patterns.

Each set was arranged as a Latin Square with the following treatments:

(1)	**Check**	No treatment.
(2)	**p**	Superphosphate, 400 lb. per acre.
(3)	**pm**	Superphosphate as in (2) with 10 tons manure per acre.
(4)	**pp_1**	360 pounds superphosphate per acre plus pyrophosphate, the combined amount of phosphorus being equivalent to that in 400 lb. superphosphate.

The clippings were cut with shears when the sward reached a height of 6 inches or more. The pots without frost were clipped four times in a period of 84 days and those with frost three times in 59 days. The method of analysis was the same as that employed for the radioactive plant material (6). The data from these sets of clippings are combined in Table 2 along with the statistical evaluation of the treatments.

DISCUSSION OF RESULTS

Significant differences in the yield of dry matter are found between the dates of clipping, as shown in Table 4. These differences in growth are attributable to the pattern of the precipitation rather than to the treatments. The relationship of the yield from the whole area sampled to rainfall and the pattern of the maximum temperature is shown in Figure 1. The rainfall is expressed as the cumulative pattern from one date of clipping to the next, the moisture remaining in the soil in May, the week of early July and in September in sufficient amounts to promote vigorous growth.

The lack of growth response to the top-dressings warrants some comment. An adequate supply of calcium, magnesium and potash in the upper layer of this soil is indicated by the chemical analysis, Table 1. The unusually high values for potassium suggests an accumulation of this plant nutrient. Possible sources for this are the presence of a large amount of decomposing plant and manure residues in the surface layer which are high in potassium or possibly the upward capillary movement of soluble potassium with resulting concentration by evaporation. Rideau clay also has a rather high natural supply of nitrogen and phosphorus nutrients (10). The reason for the yield response to the manure for the clippings taken July 4, but not for the other dates, is not apparent from this experiment. The relatively low yields from this permanent pasture may be attributable to factors other than soil fertility and may possibly include the botanical composition of the herbage and soil compaction. The lack of response to phosphatic fertilizer indicates that phosphorus is not the limiting factor to growth on this pasture.

The phosphorus content of the herbage from this pasture is found to be significantly different at different times during the growing season (Table 4). The relationship of the rainfall, maximum temperature and average phosphorus content is shown in Figure 2. It is worthy of note that the clippings taken during periods of rapid growth, the two in May, and the one in September have greater phosphorus content than those in June or July. According to this experiment the phosphorus which the grazing

animal can get from the herbage might be in greater supply during the periods of rapid growth of the herbage. In the supplementary experiment carried out in the greenhouse all three phosphatic treatments, with and without frost treatments, were effective in increasing the phosphorus content of the herbage (Table 2). In the field studies the top-dressing with superphosphate applied in the spring or by manure applied in the fall brought about an increase in the phosphorus content of the herbage, although this was not consistent from one date of clipping to another Table (4). The phosphorus content is not increased in the herbage by the superimposition of the top-dressings as in treatments 5, 6, 7, 8.

The present studies indicated that the herbage on this pasture contained from 4 to 7 pounds of phosphorus per acre with a yield of about 1400 pounds of dry matter. The 40* pounds of phosphorus supplied in the top-dressing of superphosphate was a source of a portion of the phosphorus in the herbage receiving this treatment, as indicated from the experiments with the labelled superphosphate (6).

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THE RESPONSE OF VARIOUS FORAGE CROPS TO SALINE SOILS[1]

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ABSTRACT

Tests conducted in the field and greenhouse on natural alkali soil from 1947 to 1951 show that slender wheat grass *Agropyron trachycaulum* (Link.) Malte. and tall wheat grass *Agropyron elongatum* (Host.) Beaux., were the most alkali tolerant of all crops tested. Slender wheat grass was better suited to drier saline areas than tall wheat grass. Tolerance of legumes was very uncertain and they were hard to establish on alkali soils. The annual crops are very susceptible in the advanced seedling stage.

White alkali is frequently found on the brown and dark brown soil zones of Western Canada, but black alkali rarely occurs. Mitchell (7) has stated that 1,000,000 acres of alkali soils are found in the surveyed area of Saskatchewan alone. Alkali soils are less frequent in Manitoba. In Alberta, in addition to natural alkali areas, additional acreages are being developed as a result of irrigation.

Plants show considerable variation in tolerance to alkali. Most cultivated crops are not tolerant to alkali. Many uncultivated species, including perennial grasses, show considerable tolerance. This study was undertaken to obtain information on the alkali tolerance of forage crops commonly grown in Western Canada and of grass species recently introduced to this region from Europe. It was hoped that a more critical evaluation of the tolerance of forage crops to alkali would assist in converting unproductive alkali areas into useful hay and pasture lands.

LITERATURE REVIEW

Palmer (8) found that in the presence of sulphate salts, the tolerances of established crops were in decreasing order of: western rye grass, brome grass, Kentucky blue grass, meadow fescue, and alsike clover. Doughty and Stalwick (1) showed that 0.4 per cent water soluble salts was approximately the upper limit for fair crop growth. At concentrations of 1.096 per cent salt, there were reductions in yield of wheat, oats and alfalfa from 33 to 77 per cent. Alfalfa was more resistant to higher concentrations than wheat or oats.

McKenzie and Bolton (6) considered oats, sorghum and millet to have merit on alkali soils in the Val Marie area of Saskatchewan. Annual crops that were unsuitable were: wheat, barley, flax, rye, sugar beets, mangels, turnips, corn, rape, peas, vetch, soybeans, annual sweet clover and sudan grass. The best suited perennial grasses were slender wheat, brome grass, crested wheat grass, meadow fescue and reed canary grass. Tall oat grass, creeping red fescue and timothy were less alkali tolerant.

[1] Contribution from the Dominion Forage Crops Laboratory, Saskatoon, Sask., being a condensation of a thesis submitted to the Graduate School of the University of Saskatchewan in partial fulfilment of the Degree of Master of Science.

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McKenzie (5) had difficulty in obtaining good stands of clover and alfalfa on alkali soils. Small concentrations of salts were found less toxic to alfalfa in the seedling stage than at germination. Magistad (4) found no variety of strawberry clover to outyield alfalfa or ladino clover on alkali soils.

Kearney (3) and Magistad (4) showed that timothy, orchard grass, and red top could succeed in salt concentrations as high as 0.5 per cent. Brome grass, western wheat grass, Italian wild rye, meadow fescue, crested wheat, slender wheat and tall oat grass were the most resistant crops that could be used on alkali soils. For these crops, the upper limit of salt tolerance was 0.8 per cent. However, it was found that brome grass could produce a good seed crop in concentrations as high as 0.7 per cent salt and a good forage crop in concentrations as high as 1.0 per cent salt.

Various difficulties are encountered when testing crops on alkali soils. At the United States Salinity Laboratory, Riverside, California (9) it was found that in general, plants showed few characteristic symptoms of salt injury unless the salt concentration was very high. The outstanding growth response to saline soil solutions was a reduction in the size of the plant.

MATERIAL AND METHODS

During 1947 to 1951, six field tests were conducted on alkali areas near Saskatoon, Sask. Tests were located on the edge of alkali sloughs so as to get a gradation in salt concentration. Four greenhouse tests were also conducted on seven natural alkali soils taken from the field test areas. These tests were conducted in duplicate greenhouse flats, 12 inches by $6\frac{1}{2}$ inches. Notes were taken on vigour of plants at different intervals after seeding. Watering was kept at minimum to prevent excess leaching of soluble salts.

TABLE 1.—BOTANICAL NAME, COMMON NAME, AUTHOR AND VARIETY OF THE GRASS SPECIES USED IN FIELD AND GREENHOUSE TESTS ON ALKALI SOILS

Botanic name	Common name	Variety
**Agropyron elongatum* (Host) Beaux.	Tall wheat grass	S-68
**Agropyron intermedium* (Host) Beaux.	Intermediate wheat grass	Ree, "Glaucum"
**Agropyron cristatum* L.	Crested wheat grass	Fairway
**Agropyron desertorum* Fisch (Schult)	Crested wheat grass	Standard
**Agropyron trachycaulum* (Link) Malte	Slender wheat grass	Mecca
Agropyron Smithii (Scribn) Smith	Western wheat grass	
**Bromus inermis* Leyss.	Brome grass	Achenbach
**Bromus inermis* Leyss.	Brome grass	Commercial
**Elymus junceus* L.	Russian wild rye	S-114
Elymus candensis L.	Canadian wild rye	Mandan
Festuca elatior var. *arundinacea* L.	Tall fescue	
**Elymus macounii* Vasey	Macoun's wild rye	
Elymus arenarius L.		
Elymus virginicus L.	Virginia wild rye	
Elymus sibiricus L.	Siberian wild rye	
Festuca rubra L.	Red fescue	
Phalaris arundinacea L.	Reed canary grass	Common
**Hordeum jubatum* L.	Wild barley	

* Grass species used in greenhouse tests.

Soil analyses were conducted on all tests in 1950. In field test No. 2, since the plots were running from an area of low concentration to an area of high concentration, definite cut-off points could be determined for each crop. The soil was sampled (1) where there was good crop growth; (2) at the crop cut-off point, and (3) where there was no crop growth for plots of each individual crop. Salt content was measured in terms of electrical conductivity (millimhos/cm.) as described by Hayward and Wadleigh (2). Electrical conductivity was regarded as the most suitable measure for appraising soil salinity and its relation to crop conditions and plant growth. It was expected that an electrical conductivity of the saturation extract equal to 4 millimhos/cm. (mmhos/cm.) would cause significant reduction in growth for crops listed as having poor salt tolerance. Moderately tolerant crops would do well where the conductivity did not exceed 8 mmhos/cm. Crop growth would be restricted if the conductivity was between 8 and 15 mmhos/cm. and no crop and few species of natural halophytes would do well at conductivities in excess of 15 mmhos/cm.

The grasses that were used in the tests are listed in Table 1.

Elymus macounii is a natural cross between slender wheat grass and wild barley as indicated by work carried out at the Dominion Forage Crops Laboratory at Saskatoon. The strain used in these tests was a fertile strain formed by colchicine doubling.

EXPERIMENTAL RESULTS

Field Results

In 1947, 1948 and 1949 there was particularly poor germination in test No. 1. This was partly the result of drought and partly the result of high salinity (conductivity 12.72 millimhos/cm.). However, species showing some germination were *Agropyron* spp., *Bromus* spp., *Melilotus* spp., cereal crops, rape and sorghum. Polish rape appeared better than Argentine rape.

TABLE 2.—SEEDLING VIGOUR SCORES* AND CONDUCTIVITY READINGS FOR ALL FIELD TESTS CONDUCTED DURING THE SUMMERS OF 1949 AND 1950

Time of seeding	Test number				
	2	3	4	5	6
	Fall	Fall	Spring	Fall	Fall
Conductivity reading in millimhos/cm.	5.80	8.68	4.25	0.61	0.87
	1949-1950 2-year av.	1950	1950	1950	1949-1950 2-year av.
Achenbach brome grass	4.5	4.5	4.8	7.0	6.7
Commercial brome grass	0.8	3.5	4.8	5.3	6.2
Intermediate wheat grass (Ree)	4.0	6.0	2.1	5.3	7.2
Tall wheat grass	7.1	6.5	6.3	4.6	5.0
Fairway crested wheat grass	0.3	7.5	6.3	3.6	6.0
Standard crested wheat grass	0.3	3.0	3.5	3.6	5.5
Slender wheat grass	8.0	8.5	8.6	8.2	7.2
Russian wild rye	5.5	8.5	2.4	6.4	5.5
Ladak alfalfa	2.3	2.0	8.4	8.2	1.7
Arctic sweet clover	2.4	2.0	5.3	0.0	8.5

* Basis 0 (no stand) to 10 (good growth).

Table 2 presents data on seedling vigour scores for all field tests conducted for 1949 to 1950. In all field trials slender wheat grass showed up better than any other crop tested. In tests, where the conductivity reading of the soil was high, this crop was better, in most cases, than any other crop tested. Other crops that performed very well were tall wheat grass (10), Russian wild rye, Achenbach brome grass and Ladak alfalfa.

Figure 1 shows a good stand of cereal crops in test No. 2 in 1948. Cereal crops emerged better than forage crops during this dry year. However, production from these crops was very poor on alkali soils. Tolerance in the annual crops was in the order of oats, barley, flax, rye, wheat and rape.

For the past five years seedings have been made on saline soils in both the fall and spring. The fall seedings have given the best forage stands. Spring seedings were usually poorer and in most cases no stands were obtained. Therefore, most of the tests were sown in the fall with good results.

Table 3 presents hay yields for test No. 4 in 1951. The reduction in yields of crops on the B location compared with those on the A location is an indication that soils with conductivity readings of 4.25 and total salts of 0.216 per cent may cause serious reductions in yields. This would

TABLE 3.—FORAGE YIELD OF VARIOUS CROPS AND SOIL DATA FOR TWO LOCATIONS OF TEST NO. 4. TEST SOWN MAY, 1950. CUT FOR HAY AUGUST, 1951. YIELD AVERAGE OF DUPLICATE PLOTS

	Yield data		
	Hay yield in tons/acre		Forage score*
	Location A	Location B	Location B
Achenbach brome grass	0.27	0.35	5.0
Commercial brome grass	0.39	0.33	5.0
Fairway crested wheat grass	0.39	0.14	3.5
Standard crested wheat grass	0.42	0.13	3.0
Tall wheat grass	0.40	0.14	4.5
Slender wheat grass	0.90	0.35	6.5
Intermediate wheat grass (Ree)	0.62	0.25	4.5
Intermediate wheat grass (*A. glaucum*)	0.90	0.65	6.0
Russian wild rye	0.09	0.04	2.5
Canadian wild rye	0.56	0.53	6.0
Ladak alfalfa	0.41	0.08	2.5
Arctic sweet clover	0.80	0.48	6.5
Oats	—	0.49	—
	Soil data		
Conductivity surface (1″-6″) mmhos/cm.	2.45	4.25	—
Conductivity subsoil (6″-12″) mmhos/cm.	3.63	4.36	—
Per cent salt (1″- 6″)	0.147	0.216	—
Per cent salt (6″-12″)	0.161	0.222	—
Soil reaction (1″- 6″) pH	7.9	7.9	—
Soil reaction (6″-12″) pH	8.2	8.0	—

* Basis 0 (no yield) to 5 (good yield).

TABLE 4.—CONDUCTIVITY RATINGS IN MMHOS/CM. ON PLOTS OF INDIVIDUAL CROPS OF TEST NO. 2, 1950

	Good growth		Cut-off point		No growth	
	Surface soil	Sub-soil	Surface soil	Sub-soil	Surface soil	Sub-soil
	1"-6"	6"-12"	1"-6"	6"-12"	1"-6"	6"-12"
Slender wheat grass	4.92	10.65	15.13	23.98	17.65	28.54
Intermediate wheat grass (Ree)	3.50	10.30	4.52	12.80	8.64	27.70
Western wheat grass	2.33	2.96	3.71	6.76	4.02	10.70
Fairway crested wheat grass	3.45	7.48	4.02	7.87	8.34	29.40
Standard crested wheat grass	—	—	2.94	6.38	4.59	11.06
Tall wheat grass	3.45	7.48	15.13	23.98	21.87	28.80
Achenbach brome grass	3.87	12.23	5.16	15.50	10.40	27.10
Commercial brome grass	2.33	2.96	4.02	7.87	5.42	11.30
Russian wild rye	3.47	9.51	3.22	10.80	15.90	27.10
Reed canary grass	—	—	2.94	6.38	4.59	11.06
Grimm alfalfa	—	—	8.77	18.20	11.10	29.60
Arctic sweet clover	—	—	3.28	7.22	4.37	12.30

indicate that the soil conductivity rating of 4 given by Hayward and Wadleigh (2) for the upper limit for normal growth may be too high and that more studies should be conducted along these lines. Yields at the B location indicate remarkably good performance of intermediate wheat grass (*Agropyron glaucum*). Canadian wild rye, slender wheat grass, brome grass and sweet clover also performed well. The yield of oats seeded adjacent to this test was equivalent to that of the more alkali tolerant grasses.

Table 4 presents data on the relation of growth of species to conductivity ratings. The cut-off point gives the upper limit of salt concentration that each crop will withstand. Slender wheat grass and tall wheat grass were the two most tolerant crops in the test, growing on soils with conductivity readings up to 15.13 mmhos/cm. On concentrations above this, only native salt grasses and halophytes grew successfully. Alfalfa ranked third in tolerance, growing on soils with conductivity readings as high as 8.79 mmhos/cm. Other crops in the test grew only on soil of low conductivity readings and could be classified in the moderately resistant or susceptible groups. Figure 2 gives a general picture of this area and some indication of the cut-off points for crops in this test.

Greenhouse Results

Results from tests No. 7, 8, and 9 (Table 5), conducted on seven different soils, show that after 7 and 14 weeks of testing slender wheat grass, tall wheat grass and Macoun's wild rye were the outstanding crops in the test. They were better than any of the cereal crops except Hannchen barley. Other crops that showed up well were Russian wild rye, Ladak alfalfa, Arctic sweet clover and Argentine rape. In the test, Macoun wild rye does appear to have some tolerance, being intermediate between the purported parents.

FIGURE 1. Growth of cereal crops on Test No. 2 in 1948. Note the good growth made by the cereals in the central portion of the picture. Bare ground to the left and right of the cereals was seeded to forage crops but no stands were obtained. Foreground—saline area where cereals would not germinate and immediate foreground sea blite (*Suaeda depressa* Pursch. S. Wats.).

FIGURE 2. Portion of Test No. 2, 1950, sown 1949. The plots showing are as follows:

27 Tall wheat grass.
28 Fairway crested wheat grass.
29 Reed canary grass.
30 Slender wheat grass.
31 Tall wheat grass.
32 Intermediate wheat grass (Ree).

FIGURE 3. Slender wheat grass (*top*) and tall wheat grass (*bottom*) grown on various soils in Test No. 7, 1951 greenhouse seeding. Conductivity readings on various soils from left to right were 0.59, 0.61, 0.87, 4.23, 5.80, 8.68, 12.72 mmhos cm. respectively.

FIGURE 4. Fairway crested wheat grass (*top*) and standard crested wheat grass (*bottom*) grown on various soils in Test No. 10, 1951 greenhouse seedings. Conductivity readings on the various soils from left to right were 0.59, 0.61, 0.87, 4.25, 5.80, 8.68 and 12.72 mmhos/cm. respectively.

Eighteen weeks after planting (in test No. 7), tall wheat grass was better than any other crop. It is important to note that the cereal crops were completely eliminated after 18 weeks of testing. This would indicate that cereal crops become very susceptible to salt in the advanced seedling stages.

To give a better comparison of the effect of alkali on the two most tolerant and the two most susceptible crops in the greenhouse tests, Figures 3 and 4 are presented.

TABLE 5.—GREENHOUSE RESULTS ON AVERAGE SEEDLING VIGOUR SCORES* AT DIFFERENT STAGES FOR TESTS NO. 7, 8, 9

	Test No. 7		Test No. 8	Test No. 9
	7 Weeks after seeding	18 Weeks after seeding	14 Weeks after seeding	14 Weeks after seeding
Fairway crested wheat	4.0	2.0	5.2	4.3
Standard crested wheat	5.5	2.8	5.2	4.0
Mecca slender wheat	8.2	2.8	6.2	5.5
Tall wheat	8.9	6.0	6.7	7.5
Intermediate wheat (Ree)	3.5	2.8	5.0	4.5
Common brome	4.8	3.2	5.1	5.2
Achenbach brome	5.8	3.5	4.1	4.4
Russian wild rye	6.0	3.5	6.5	4.5
Macoun wild rye	—	—	7.1	6.0
Wild barley	—	—	6.6	4.2
Ladak alfalfa	7.0	2.8	3.2	4.8
Arctic sweet clover	7.5	3.2	4.0	3.8
Argentine rape	6.5	1.2	—	—
Polish rape	4.8	0.0	—	—
Thatcher wheat	4.5	0.0	—	—
Banner oats	5.2	0.0	—	—
Hannchen barley	6.0	0.5	—	—
Royal flax	3.5	0.0	—	—
Prolific spring rye	3.2	0.0	—	—

* Basis 0 (no stand) to 10 (good growth).

TABLE 6.—RESULTS OF SOIL ANALYSES CONDUCTED ON GREENHOUSE FLATS AT TIME STARTED AND AT THE END OF THE TEST

		pH	Conductivity	SO_4	Cl
Check	Start of test	6.0	1.59	Little	Trace
	End of test (1)	6.1	2.12	Medium	Trace
	(2)	6.1	1.28	Little	0
Alkali Sample A	Start of test	7.9	9.72	Strong	Medium
	End of test (1)	7.9	8.48	Strong	Light
	(2)	7.9	7.39	Strong	Light
Alkali Sample B	Start of test	8.1	15.9	Strong	Light
	End of test (1)	8.1	13.1	Strong	Light
	(2)	8.1	12.7	Strong	Light

(1) Was planted November 21 and tested March 11.
(2) Was planted January 15 and tested April 2.

Soil analyses were conducted on greenhouse flats to determine whether leaching would cause a loss in salts. These results are presented in Table 6.

The results in Table 6 show that there has been some slight leaching but not a great deal. One irregularity in the data is the high conductivity for the check soil at the end of the first test. This might be due to the fact that this soil might not have been mixed thoroughly when placed in the flat. Otherwise the use of flats in tests such as this is very successful.

DISCUSSION

Field and greenhouse tests conducted from 1947 to 1951 indicate that slender wheat grass and tall wheat grass are the two most resistant grasses for saline conditions. On a single trial, where growth cut-off points were obtained, these crops grew on soils with conductivity readings as high as 15.13 mmhos/cm. in all field trials; slender wheat grass was better than tall wheat grass but in the greenhouse this condition was reversed. The Achenbach strain of brome grass repeatedly performed better than the commercial strain. However, their performance in the greenhouse was also reversed. This could be explained by the fact that Achenbach and slender wheat grass possess more drought resistance and would do better under dry saline conditions. The procedure of using greenhouse flats in the greenhouse has proven to be very successful. Results on conductivity readings taken before the test started and at the end of the test period showed very little leaching of salts from the soil.

The position which legumes hold in tolerance is very uncertain. In greenhouse tests the sweet clover and alfalfa appear to be about equal in tolerance. However, in the field tests, they are very variable in tolerance. Stands of these crops were generally hard to establish but once established they were very tolerant to alkali. This was especially so in the case of alfalfa.

The use of conductivity readings has proven to be a very successful method of measuring soil salinity. By using this method one is able to determine the amount of salts that is injurious to the plant under natural growing conditions. However, it should be noted, from Table 3, that there is an indication that a rating of 4 mmhos/cm. for the upper limit of normal *plant growth* may be too high and that more work should be conducted along these lines.

At present there is no extremely alkali-tolerant forage crop. There is no crop that could be recommended where natural alkali species do not grow and in areas where the conductivity readings are over 15.13 mmhos/cm.

Drought was one of the greatest difficulties encountered in getting good stands on alkali soils. However, better stands were obtained from the late fall seeding than from spring seeding. To get good stands on alkali soils it is important to obtain seed germination when the moisture content of the soil is high.

Possible mixtures which could be recommended to farmers, if the saturation extract conductivity reading of soil sample does not exceed 8 mmhos/cm., are brome and alfalfa, or brome, crested wheat grass (Fair-

way) and alfalfa. However, if conductivity readings are above this, slender wheat grass should be recommended for the drier areas and tall wheat for the wet areas or a mixture of the two could be used where moisture conditions are intermediate.

SUMMARY

1. Field tests were conducted on six different alkali areas in Saskatchewan by the Dominion Forage Crops Laboratory at Saskatoon. These tests included various species of grasses, legumes and cereal crops that are commonly grown in Saskatchewan.
2. Four different greenhouse tests were conducted from 1949 to 1951 on natural saline soils taken from the field test areas. In these tests the same perennial and annual crops were used as in field tests.
3. Results indicate that slender wheat grass and tall wheat grass were the most alkali resistant of all crops tested. Slender wheat grass was better under dry conditions and tall wheat was better under wet conditions.
4. Alfalfa was highly resistant to alkali, but it may be difficult to establish stands of this crop on alkali soils.
5. Macoun's wild rye was equal to slender wheat grass and wild barley in tolerance to alkali.
6. Moderately resistant crops were Achenbach and Commercial brome grass, Ree intermediate wheat grass, Fairway crested wheat, Canadian wild rye, Russian wild rye and sweet clover.
7. The results show that the susceptible crops were western couch grass, standard crested wheat and the annual crops.

ACKNOWLEDGMENTS

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THE INFLUENCE OF TIME OF PLANTING ON THE YIELD AND COMPOSITION OF SOYBEAN SEED[1]

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ABSTRACT

Planting soybeans at the normal seeding time gave the highest yield and the highest percentage of oil in the seed.

Delayed planting decreased the yield and lowered the oil content of the seed and the longer the delay, the greater the reductions became.

Delayed planting showed a tendency to increase both the protein content of the seed and the iodine number of the oil.

Reduction in yield, resulting from delayed planting, was caused by a reduction in the number of seeds produced, rather than by a decrease in seed size.

INTRODUCTION

The soybean crop in Canada has shown a remarkable increase in production since 1941 and there is every indication that it will show further increase in the immediate future. In 1941, the crop comprised 11,000 acres with an estimated yield of 200,000 bushels valued at about $200,000, while in 1952 the acreage amounted to 172,000 acres, which produced 4.2 million bushels valued at approximately 10 to 12 million dollars. Practically all of this production was in Ontario, and more particularly southwestern Ontario; but the development of superior, early maturing varieties is extending production into new and wider areas. The great bulk of the beans produced at present go to the processing mills for oil extraction purposes and, because the unit value of the oil is much greater than that of the extracted meal or residue, the processing companies are greatly interested in stimulating the production of those varieties that are known to be high in oil content.

Oil content of the beans is definitely a varietal characteristic, but irrespective of whether a variety is characteristically high or low in oil, it is well known that environmental conditions exert a marked influence upon its ultimate percentage. Differences in oil content as great as 2 or 3 per cent have been observed in seed of the same variety, produced at different locations in the same season, even when the locations are all within the area to which the variety is adapted. It is important, therefore, that, in order to obtain the highest percentage of oil, as well as high yield in any variety, the most favourable environment possible be provided for growth and development. The object of this study was to determine the influence of time of planting upon the yield and the chemical composition of soybean seed.

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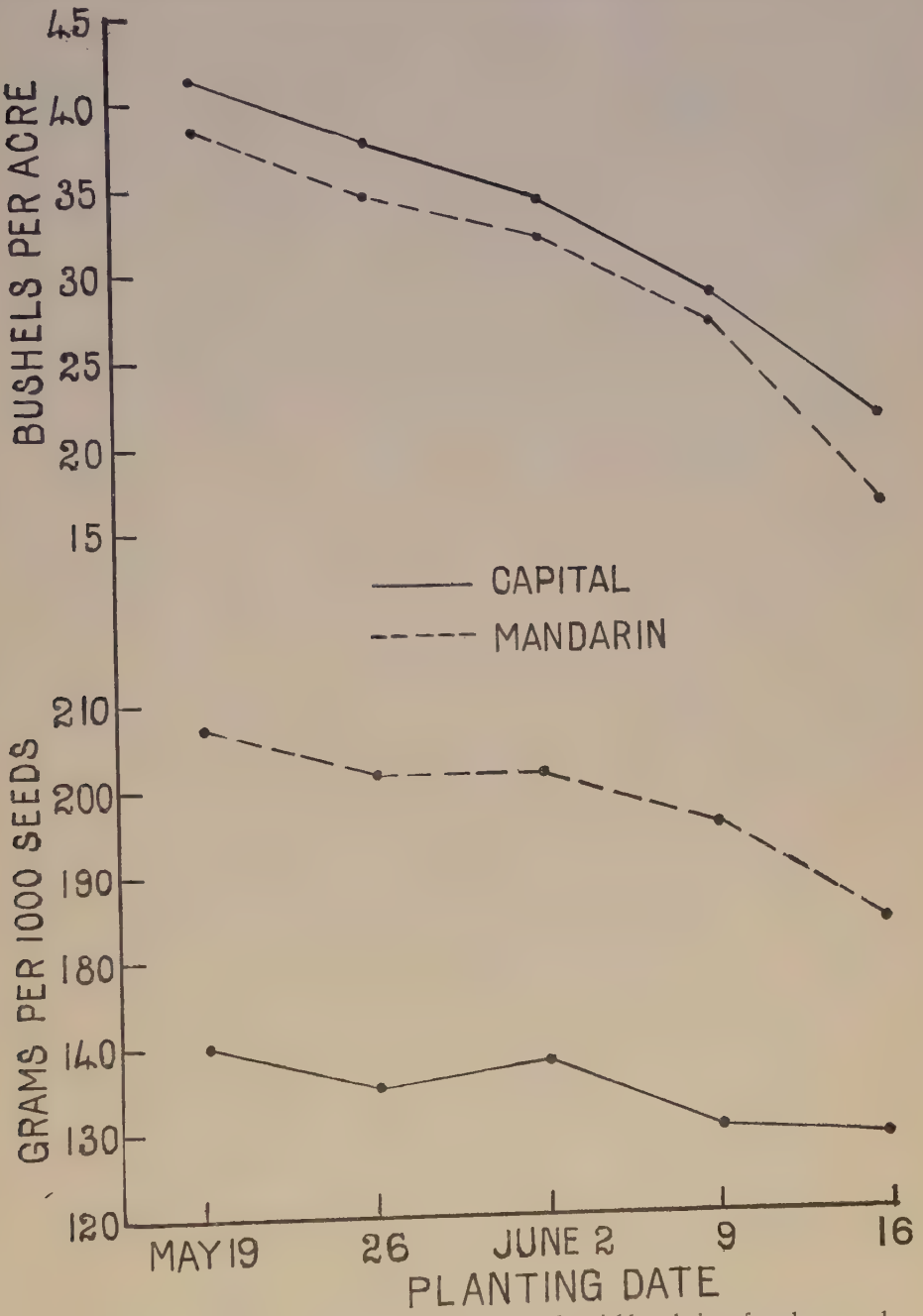

FIGURE 1. Influence of time of planting upon the yield and size of soybean seed.

LITERATURE REVIEW

Several investigators in the United States have studied environmental influences, including time of planting, upon various agronomic and chemical characters of soybeans. Weiss *et al.* (8) in a study of 10 varieties at three locations reported that, considering all varieties, progressively lower yields were obtained at dates of planting subsequent to May 1. They found however, a differential response among the varieties according to varietal maturity. Seasonal conditions also modified the effect of planting date on yield. They state that date of planting produced no definite trend with respect to protein content of the seed, but delayed planting tended to decrease the oil content slightly (more particularly in the late varieties), and materially increased the iodine number of the oil. Effects of delayed planting on seed size were inconsistent. Cartter and Hopper (2) harvested the Illini variety at six successive dates, from the full-podded, late vegetable stage to complete maturity, and found only a small change in seed size due to time of harvest. Morse *et al.* (5) conducted time-of-seeding studies in the Corn Belt and showed that delaying the planting of an adapted variety three weeks beyond the optimum date will generally reduce seed yields and the oil content of the seed. Feaster (4), in a study involving five varieties during a period of four years, reported that the latest planting yielded the lowest and gave the lowest content of oil. Iodine number of the oil tended to increase with lateness of planting. Burlison *et al.* (1) found that, as an average of 12 varieties, May seedings produced higher grain yields than June seedings; while O'Kelly *et al.* (6) reported that beans of four Mammoth yellow strains, harvested before maturity, contained a higher percentage of protein and fat, but gave a considerably lower iodine number of the oil than mature beans.

MATERIALS AND METHODS

Two varieties of soybeans, namely, Capital and Mandarin, were used in this study. Capital is slightly earlier maturing than Mandarin and in addition is higher in yield and the seed is higher in oil content. Capital is regarded as a high oil variety, while Mandarin is considered a medium oil variety. Both are recognized as full-season varieties at Ottawa.

The experiment with Capital was begun in 1950, while that with Mandarin was started in 1951. Five plantings were made of each variety each year, with four replications of each planting. Plots consisted of three rows, 30 inches apart and 20 feet long, with only the centre row harvested for yield and other data. Beginning with the first planting at the normal time of seeding, subsequent plantings were made at weekly intervals, so that the fifth planting was seeded four weeks later than the first planting. All seeding was done by hand. Two seeds were dropped every 3 inches in the rows and the stand was thinned to a single plant every 3 inches shortly after emergence. Plots were harvested and threshed in a single day, about mid-October each year, after frost prevented any further growth. At that time the first, second and third plantings appeared to be quite well matured, while the fourth and fifth plantings still showed evidences of immaturity. Seed yields were calculated to 14 per cent moisture basis. A composite

TABLE 1.—YIELD PER ACRE (ACTUAL AND RELATIVE) FROM FIVE PLANTINGS OF CAPITAL AND MANDARIN, TOGETHER WITH THE 1000-SEEDS WEIGHTS

Planting	Yield, bu. per acre (14% moisture)								1000-seeds weight (grams)					
	1950		1951		1952		Average		1951		1952		Average	
	act.	rel.	act.	rel.	act.	rel.	act.	rel.	act.	rel.	act.	rel.	act.	rel.
Capital														
1. May 19	41.5	100	36.3	100	46.8	100	41.5	100	125	100	154	100	140	100
2. May 26	38.8	93	30.6	84	43.9	94	37.8	91	126	101	143	93	135	96
3. June 2	34.4	83	28.9	80	40.3	86	34.5	83	129	103	146	95	138	99
4. June 9	24.1	58	20.6	57	41.7	89	28.8	69	109	87	151	98	130	93
5. June 16	16.9	41	17.8	49	30.2	65	21.6	52	109	87	149	97	129	92
L.S.D.	3.1		4.3		6.2									
Mandarin														
1. May 19	—	—	35.2	100	41.6	100	38.4	100	197	100	217	100	207	100
2. May 26	—	—	31.0	88	38.0	91	34.5	90	200	102	203	94	202	98
3. June 2	—	—	27.2	77	37.3	90	32.3	84	201	102	203	94	202	98
4. June 9	—	—	16.8	48	37.4	90	27.1	70	195	99	197	91	196	95
5. June 16	—	—	10.0	28	22.4	54	16.2	42	181	92	187	86	184	89
L.S.D.	—	—	3.8		6.8									

sample of seed, obtained from the four replicates of each of the five plantings, was used for chemical analysis, which included the percentages of protein and oil, and the iodine number of the oil. All chemical analyses were determined on a moisture-free basis.

EXPERIMENTAL RESULTS

The data presented in Table 1 show the yield per acre from each of the five plantings of Capital and Mandarin for the years, 1950 to 1952. Percentage or relative yields of the delayed plantings are shown in relation to the yields obtained from the first planting as 100 per cent. The 1000-seeds weights are included to indicate the nature of the reductions in yield which resulted from delayed planting.

It is interesting to note that the data in Table 1 show a very different relationship between the extent of the percentage reduction in the yields and those of the corresponding 1000-seeds weights. Seed size was approximately the same, irrespective of time of planting and its effect upon yield. Both the yields and the 1000-seeds weights are illustrated graphically in Figure 1.

Figure 2 shows typical plants taken at the time of harvest from the first and fifth plantings of both Capital and Mandarin. It will be noticed that the pods on the plants from the fifth planting are greatly reduced in number as compared with the first planting and are confined largely to the lower portion of the plants. This is particularly true in the case of Mandarin, in which the tips of the main stem and the branches are devoid of pods.

Data with respect to protein and oil percentage and the iodine number of the oil are presented in Table 2. In order to indicate more clearly the increase or decrease in the protein or oil content, the actual percentages are shown also on a relative percentage basis, using the first planting data as the basis for comparison.

It is quite clear from the data in Table 2 that delayed planting tended to raise the percentage of protein and lower the oil content of both varieties. These influences became more marked with each delay in planting. Some exception to this was shown in 1952, when the somewhat warmer than average seasonal conditions resulted in differences that were less marked than those obtained in 1950 and 1951. It is probable that additional delayed plantings might have been necessary to produce results similar to those of the previous two years.

While the iodine number of the oil was not greatly affected by time of planting, nevertheless each delay tended to bring about a slight but consistent increase in this value.

A graphical illustration of the effect of time of planting on the chemical composition of the seed is shown in Figure 3.

DISCUSSION

In the production of soybeans the yield and chemical composition of the seed are among the characteristics of primary importance. The grower is greatly interested in the yield while the processor is concerned

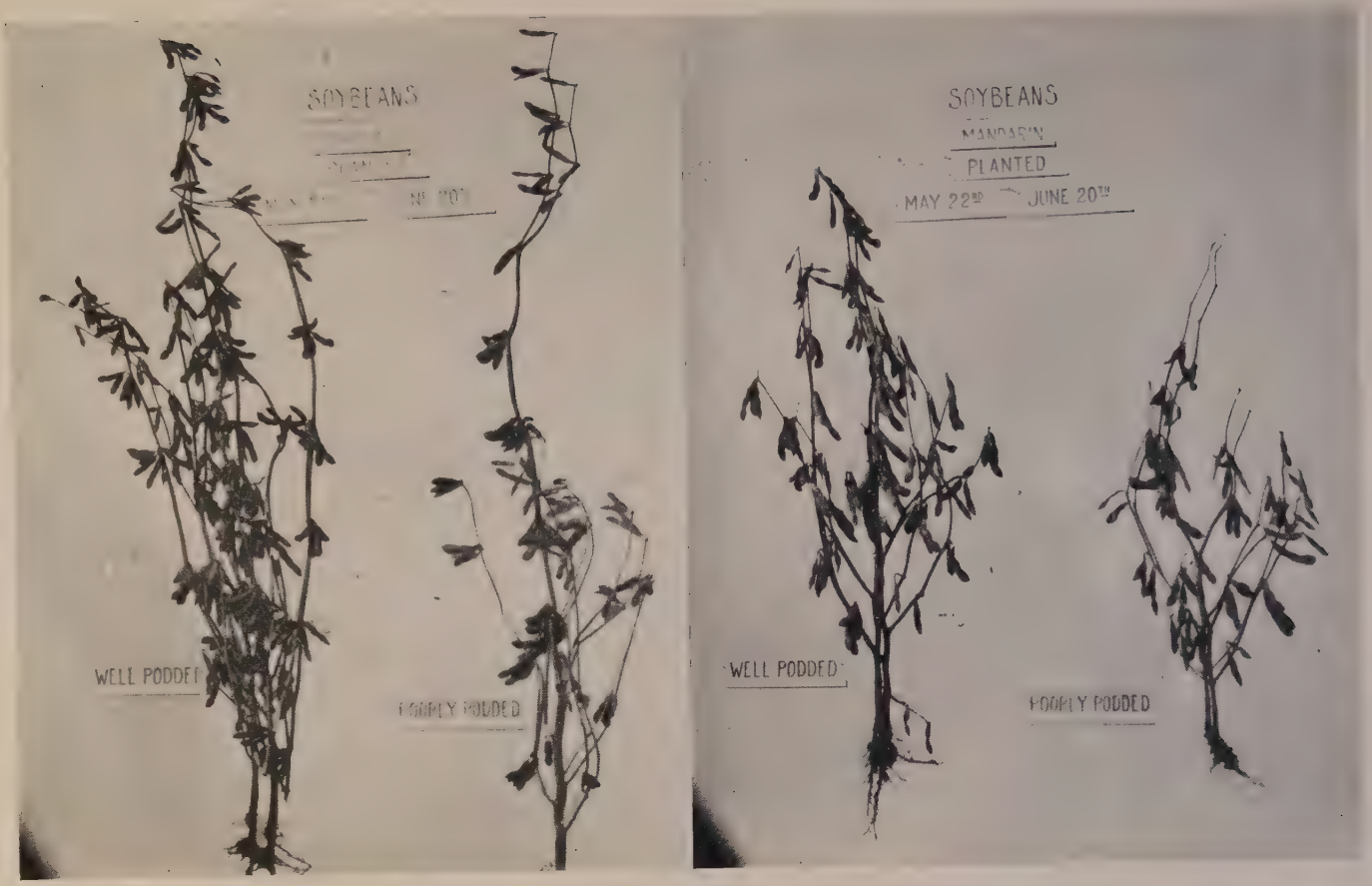

FIGURE 2. Plants of Capital and Mandarin taken at maturity from the first and fifth plantings. Note the number and location of the pods.

TABLE 2.—PROTEIN AND OIL PERCENTAGES (ACTUAL AND RELATIVE) AND THE IODINE NUMBER OF THE OIL, OF CAPITAL AND MANDARIN SEED FROM FIVE PLANTINGS*

Planting	Capital								Mandarin					
	1950		1951		1952		Average		1951		1952		Average	
	Protein percentage (actual and relative)													
	act.	rel.	act.	rel.	act.	rel.	act.	rel.	act.	rel.	act.	rel.	act.	rel.
1. May 19	40.0	100	36.8	100	39.8	100	38.9	100	40.2	100	41.0	100	40.6	100
2. May 26	39.0	98	37.2	101	40.5	102	38.9	100	43.0	107	41.4	101	42.2	104
3. June 2	41.6	104	38.6	105	41.6	105	40.6	104	43.4	108	42.1	103	42.8	105
4. June 9	40.3	101	41.1	112	41.2	104	40.9	105	44.0	109	40.5	99	42.3	104
5. June 16	43.7	109	41.9	114	39.1	98	41.6	107	45.2	112	39.4	96	42.3	104
	Oil percentage (actual and relative)													
1. May 19	18.6	100	21.1	100	19.6	100	19.8	100	18.7	100	20.0	100	19.4	100
2. May 26	18.3	98	20.2	96	19.3	98	19.3	97	17.7	95	19.1	96	18.4	95
3. June 2	17.2	92	19.2	91	18.8	96	18.4	93	17.8	95	19.3	97	18.6	96
4. June 9	15.7	84	17.2	82	18.8	96	17.2	87	16.8	90	19.1	96	18.0	93
5. June 16	15.6	84	17.1	81	18.9	96	17.2	87	16.6	89	19.8	99	18.2	94
	Iodine number													
1. May 19	138		139		135		137		134		131		133	
2. May 26	139		138		136		138		135		133		134	
3. June 2	139		139		137		138		135		132		134	
4. June 9	142		141		137		140		137		134		136	
5. June 16	141		141		138		140		139		137		138	

* Analyses by the Chemistry Division, Science Service, Ottawa.

largely with the oil content of the beans. As a consequence, the efforts of the plant breeders are at present focused on the development of varieties that will fulfil both of these requirements. In the growing of these varieties, however, the provision of a satisfactory environment is essential to secure the fullest expression of these two desirable characteristics. The time of planting by determining the length and period of the growing season creates an environmental condition which is largely under the control of the grower.

The data which have been presented show that delayed planting had a definite influence upon the yield and composition of soybean seed. For each additional delay in the planting date there was a corresponding reduction in the yield and the percentage oil content of the beans. Delaying the planting time from May 19 to June 16, a difference of four weeks, reduced the yield of both varieties approximately 50 per cent, and also reduced the actual content of oil 2.6 per cent in the case of Capital and 1.2 per cent in the case of Mandarin. In 1950 and 1951 the effects of delayed planting were much more marked than in 1952. Seasonal conditions in 1952 were somewhat warmer than average. The effects of delayed planting, therefore, may be expected to be more severe in years when seasonal conditions tend to be cooler than average. Such a season was experienced in 1951. In that year the fifth planting of Capital yielded only 49 per cent of normal, while the oil content of the seed dropped from 21.1 to 17.1 per cent, a difference of 4 per cent. The environmental effects resulting from the late planting were responsible for reducing Capital from a normally high yielding, high oil content variety to a low yielding, low oil content variety. The yield of Mandarin was even more seriously affected by the late planting in the same season. It was reduced to 28 per cent of normal, while the oil content dropped from 18.7 to 16.6 per cent. Reductions of such magnitude as these could be of serious consequence to both the grower and the processor. The success of the plant breeder in developing high yielding, high oil content varieties may be completely nullified by environmental effects brought about by delayed planting.

Both Capital and Mandarin are adapted, full-season varieties at Ottawa. It is possible that the use of an earlier maturing variety, where late planting is unavoidable, may not show the same effects as the varieties that were used. By the same token, it may be possible that a later maturing, unadapted variety would behave in a manner similar to the later plantings of Capital and Mandarin, even when planted at the normal planting time, but harvested in an immature condition. This remains to be determined. Complete physiological maturity seems to be essential for the highest expression of the two important inherent characteristics, high yield and high oil content.

Delayed planting tended to increase the protein content of the seed and the iodine number of the oil. Usually the protein and oil content of soybean seed show an inverse relationship (2, 3, 4, 7), so that any decrease in oil content resulting from delayed planting would be expected to be accompanied by an increase in the percentage of protein. This was usually the case in this experiment. With respect to the increase in the iodine number, it was not affected to the extent that it constituted any appreciable change in the characteristic nature of the oil from the standpoint of its drying properties.

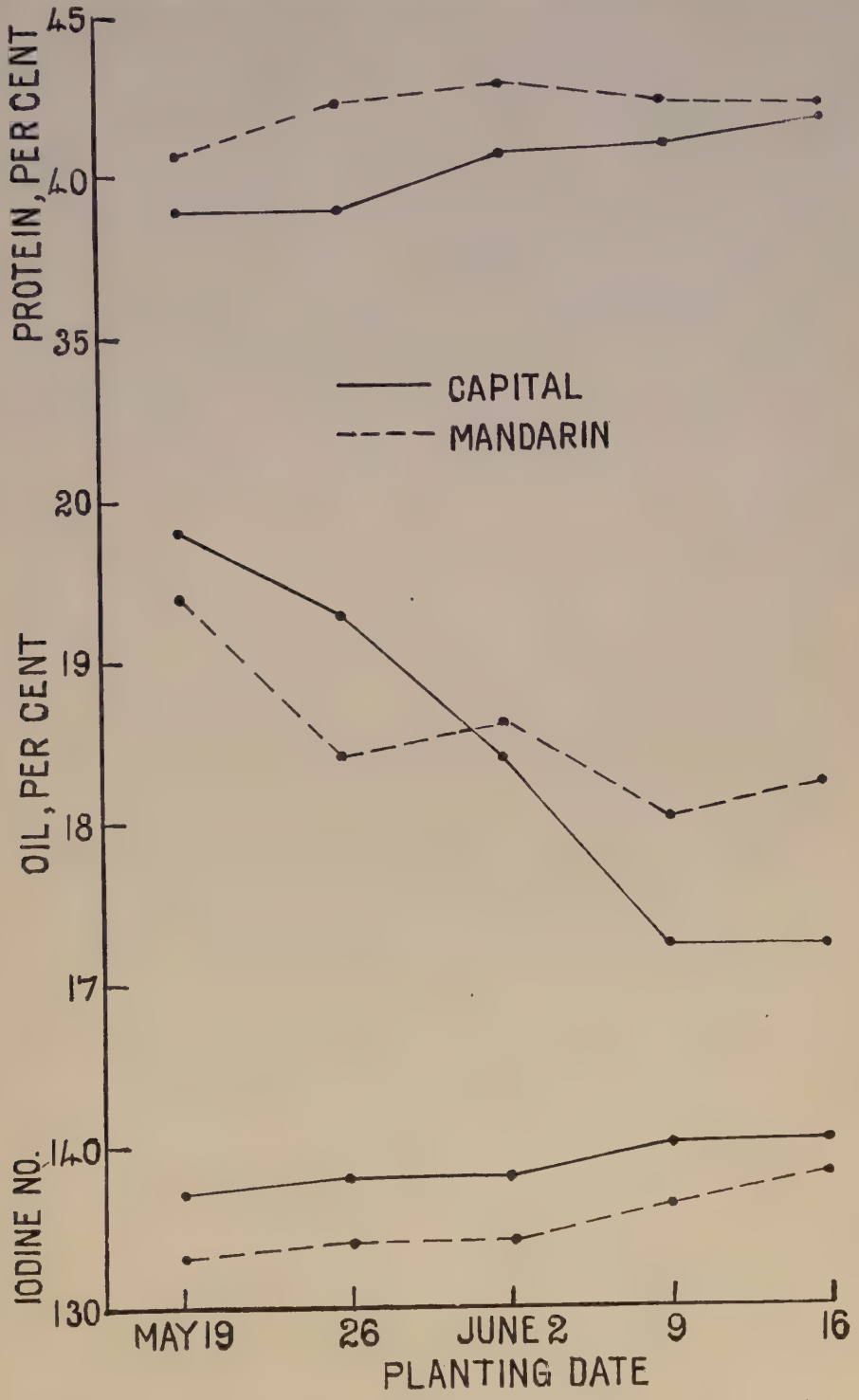

FIGURE 3. Influence of time of planting upon the composition of soybean seed.

Reduction in yield, resulting from delayed planting, was not accompanied by a corresponding reduction in the 1000-seeds weights. This was true of both varieties. Seed of almost equal size was harvested from all plantings including the two latest plantings. It shows that yield losses, due to late planting, resulted from a reduction in the number of seeds produced rather than from a reduction in seed size. This has been noticed by other investigators. Cartter and Hopper (2) state that the soybean plant regulates by physiological abortion the number of seeds that it can fill under existing environmental conditions. That observation is supported by the results of this investigation and is well illustrated in Figure 2.

This experiment was somewhat limited in its scope. It included the study of two varieties at a single location. The time of study, however, extended over a period of three years for Capital and two years for Mandarin, making a total of five tests in all. It is believed that the results were sufficiently consistent to conclude that the planting of soybeans at or near the normal date of seeding will give the best results from the standpoint of yield and the composition of the seed, particularly with respect to oil content.

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THE UPTAKE BY PLANTS OF LABELLED PHOSPHATE FROM NEUTRON-IRRADIATED CALCIUM PHOSPHATES

III. PENETRATION INTO SOIL AND UPTAKE BY PASTURE HERBAGE[1]

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ABSTRACT

Observations have been made on the penetration into the soil of the phosphorus of labelled superphosphate applied as a top-dressing to a permanent pasture sward on Rideau clay soil. It was found that more than 90 per cent of the phosphorus remained in the surface inch of the soil. Evidence also was obtained that surface-applied superphosphate migrated in run-off water.

The results obtained suggest that further investigation might reveal an effect of amount and distribution of rainfall on the relative uptakes of fertilizer and soil phosphorus by pasture herbage.

The experiment to be described was carried out on permanent pasture sward on Rideau clay soil (7) at Macdonald College, Quebec. The principal component of the sward was Kentucky blue grass (*Poa pratensis*). This was accompanied by varying amounts of wild white clover (*Trifolium repens*) and of dandelion (*Taraxacum officinale*). The principal treatments used and the dates of application were as follows:

No treatment

Pa — Topdressed with superphosphate at 400 pounds per acre on December 1, 1948.

Ps — Topdressed with superphosphate at 400 pounds per acre on April 23, 1949.

M — Topdressed with rotted manure from the dairy barn at 10 tons per acre on November 30, 1948.

These treatments, with dates of application as above, also were combined thus: Pa and Ps, Pa and M, Ps and M, Pa, Ps and M. Each plot measured 5 × 16 feet and the treatments were in quadruplicate. The experimental design and the observations made on yield and phosphorus uptake of the herbage taken from these plots, excepting the small sub-plot areas described below, are reported elsewhere (3).

The superphosphate applied was that portion of a commercial product (Canadian Industries Limited), dried at 103° C. for 16 hours, which, after being passed through a 10-mesh sieve, was retained by one of 40-mesh A sub-sample of this material was neutron-irradiated for labelling. For the latter purpose 10 grams of the irradiated material was mixed, by 12 hours' end-over-end shaking, with 50 to 60 grams of the non-irradiated

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sample. Thoroughness of mixing was assessed by measurement of the radioactivity of three sub-samples randomly drawn from the mixture; a 1.0 per cent variation in the activities of these sub-samples was tolerated.

Labelled superphosphate was applied to sub-plots one foot square within each plot receiving the inactive phosphate; both active and inactive materials were applied at the rate of 400 pounds per acre as top-dressings. The sub-plots were utilized in estimation of soil penetration by the surface-applied phosphate and of herbage uptake of fertilizer and soil phosphorus. The radioactive material was applied as evenly as possible using a modified salt-cellar. During the distribution of this material the soil surrounding the sub-plot being treated was protected by masonite sheeting. The sub-plots were similarly shielded when applications of inactive phosphate were being made to the remainder of the plot areas. For measurement of over-winter and early spring penetration of the soil each sub-plot treated received 3.4 mc. of activity as phosphorus-32. Applications of labelled phosphate made to sub-plots on April 23, 1949, for measurement of soil penetration and herbage uptake during the summer contained 0.12 mc. Supplementary applications made outside the main experimental area on June 9, 1949, contained 0.25 mc. per square foot. Analysis by methods described previously (1) indicated 40 per cent of the phosphorus-32 applied was present in the orthophosphate form.

Collection and Analysis of Samples

In sampling for soil penetration a cork borer of 2-cm. diameter was used. Borings were taken at five locations on each sub-plot at successive depths of 0″-1″, 1″-2″ and 2″-3″, respectively. Between sampling the borer was cleaned by thrusting it repeatedly into inactive soil.

The soil samples obtained were dried at 100° C. for 12 hours and the residual weights recorded. Each sample then was dispersed in a Waring blendor, the suspension transferred to a large Erlenmeyer flask, 2 grams sodium peroxide added and the mixture heated until frothing ceased; 0.5 gram NaF then was added and the suspension concentrated nearly to dryness. When cool, 100 ml. of 1 : 1 mixture of concentrated nitric acid and 70 per cent perchloric acid were added and the mixture concentrated to strong fuming of perchloric acid; a further addition of 25 ml. of the acid solution then was made and the concentration continued nearly to dryness. The residue was treated with 200 ml. of water, shaken well, and filtered. The filtrate was neutralized, 150 ml. of the ammonium molybdate reagent of Jones (5) was added, and the mixture allowed to stand for 15 minutes at room temperature. The ammonium phosphomolybdate precipitate was filtered with suction, dissolved in ammonium hydroxide solution containing citric acid (6), and reprecipitated by acidification with normal HCl solution.

Two methods were used in the estimation of the radioactivity of the phosphorus isolated in the above manner: (*a*) the precipitate was dissolved and the activity determined on 4-ml. portions of the solution using a dipping counter and, (*b*) a part of the phosphorus was reprecipitated from solution as magnesium ammonium phosphate hexahydrate and the count made using an end-window Geiger counter with a thin aluminum window. Corrections for decay, possible self-absorption and dilution were made.

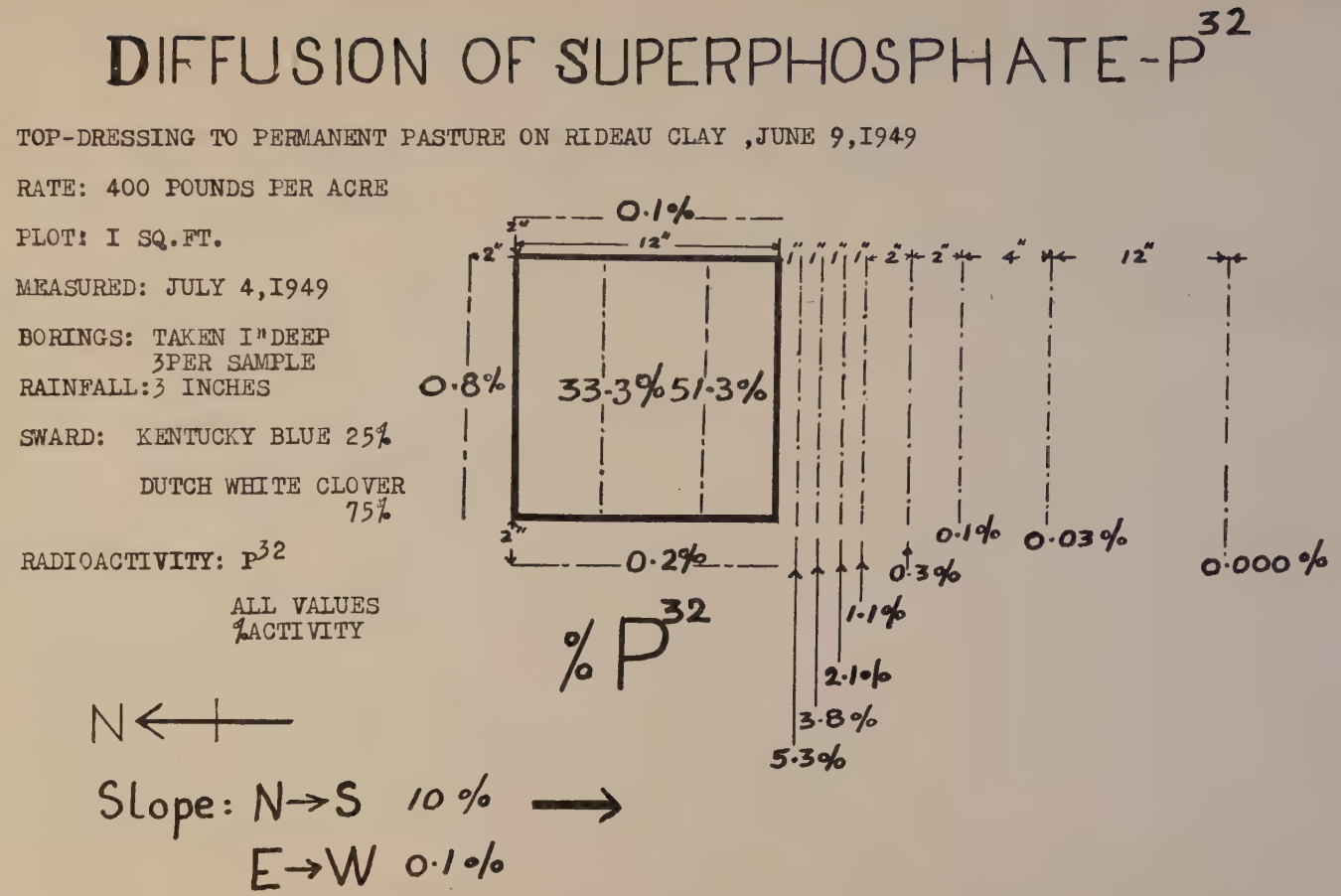

FIGURE 1. An illustration of the movement of surface-applied superphosphate.

The results were expressed as counts per minute per 100 grams of oven-dried soil. Examination showed that neither the acid-insoluble residue of the soil, nor the filtrate from the first precipitation of the phosphorus as ammonium phosphomolybdate possessed a measurable amount of radioactivity.

For the purpose of estimating plant uptake of phosphorus, the herbage on an area of 0.30 square foot was hand-clipped from the sub-plots receiving labelled phosphate. The samples were dried to constant weight at 103° C., weighed, oxidized with concentrated nitric acid solution followed by treatment with 20 ml. of an aqueous solution containing one gram of ammonium persulphate and one ml. of 70 per cent perchloric acid, and heated to strong fuming of perchloric acid. The residual solution was diluted, the phosphorus separated as ammonium phosphomolybdate followed by conversion to magnesium ammonium phosphate hexahydrate, and measurement of the radioactivity using the end-window counter. The magnesium salt then was dissolved and the total phosphorus determined using the colorimetric method of Gerritz (4).

RESULTS AND DISCUSSION

Penetration of Soil by Surface-applied Phosphorus-32

In calculating the percentage of phosphorus-32 found in the various soil layers sampled, the counts per 100 grams of soil obtained at each successive depth were summed, and the counts for the individual layers expressed as percentages of this sum. The results obtained are presented in Table 1.

TABLE 1.—PENETRATION OF PHOSPHORUS-32 SURFACE-APPLIED ON PERMANENT PASTURE SWARD

Treatment	Date of application	Date of sampling	Per cent of phosphorus-32 found at depths indicated		
			0″-1″	1″-2″	2″-3″
Pa	1/12/48	9/4/49	97.1	1.8	0.7
MPa	1/12/48	9/4/49	97.5	1.9	0.5
Ps	23/ 4/49	3/7/49	95.4	3.4	0.8
PaPs	23/ 4/49	3/7/49	94.6	4.1	1.1
MPs	23/ 4/49	3/7/49	96.5	2.9	0.5
MPaPs	23/ 4/49	3/7/49	95.1	4.4	0.8

The data of Table 1 show that, under the soil and climatic conditions of this experiment, very little of the surface-applied phosphate penetrated to a depth greater than one inch.

Lateral Movement of Surface-applied Phosphorus-32.

The possibility of movement of phosphorus-32 after application, either by splashing or by transportation by run-off water, led to observations supplementary to those on penetration to determine the presence or absence of radioactive phosphorus outside the boundaries of the area where

TABLE 2.—YIELDS OF HERBAGE (D.W.) AND ESTIMATED UPTAKES OF SOIL AND FERTILIZER PHOSPHORUS FROM SUB-PLOT AREAS DURING THE 1949 SEASON

Dates of application	Sampling dates	Rainfall received in interval, inches	Treatment	Ranges in yields and uptakes of phosphorus		
				Yield, gm./ft.^{2}	Total phosphorus content, mgm./100 gm. D.W.	Fertilizer phosphorus uptake as per cent of total phosphorus uptake
April 23	May 25	2.3*	Nil	0.86–2.45	308–505	—
			Ps	2.00–10.00	404–437	15–33
			M Ps	4.56–11.80	318–508	23–31
	July 4	4.0**	Nil	1.73– 2.48	318–466	—
			Ps	4.25– 5.32	314–497	41–50
			M Ps	5.74– 8.46	336–492	26–40
June 9	July 4	3.0*	Labelled	3.96– 5.43	320–364	27–32
	September 22	9.7**	Superphosphate	7.45–14.10	322–352	23–40
	October 22	2.0**	At 400 lb. per acre	5.67	328	17

* Rainfall between date of application and date of sampling.
** Rainfall between sampling dates.

it had been applied. At the location of the sub-plot region examined there was a slope of 10 per cent in the N-S direction with negligible slope in the E-W sense. Composite samples of three borings each were taken at varying distances from the sides of the plot and from within the plot as indicated in Figure 1. The percentages of activity at these locations are given in the figure together with information on times, rainfall, sward and borings. It would appear from the distribution found that while splash might have contributed a little to the outward movement; the primary cause of this transfer was due to run-off water.

Uptake of Phosphorus by the Herbage

Estimates of fertilizer and soil phosphorus uptake were obtainable from the sub-plots receiving labelled superphosphate in the spring and summer. Clippings of the herbage for this purpose were made at intervals during the growing season. The results obtained are reported in Table 2.

In estimating the uptake of fertilizer phosphorus it was assumed that only that fraction of the radioactive phosphorus which was present in the orthophosphate form was absorbed by the plants, that conversion of other chemical forms of phosphorus-32 to this form in the soil was negligible, and that exchange reactions did not interfere. If estimation had been made on the basis of the assumption that all of the chemical forms of radioactive phosphorus present were equally available, the proportions of the total phosphorus taken up by the herbage assigned to the fertilizer source would have been decreased to approximately 40 per cent of the values given in Table 2.

In commenting upon the results reported in Table 2, it may be noted that, while rainfall was scanty in late April and May, the soil moisture supply was adequate for satisfactory growth of the herbage during the period prior to the May 25 sampling. On the other hand, droughty conditions continuing through June considerably inhibited growth during the May 25 to July 4 interval. Ample rainfall occurred in late August and September. These climatic conditions appear to have affected the uptake of fertilizer phosphorus in the direction of an increase during the droughty May 25-July 4 period. Perhaps this may have been the result of a rapid preferential intake of this form of phosphorus following the relatively light precipitation of late June, most of the fertilizer phosphorus being in the top inch of the soil. On this soil, which earlier work (2) has indicated to be a good supplier of soil phosphorus to plants, the adequate moisture supplies available early and late in the growing season appear to have facilitated the uptake of soil phosphorus, relative to fertilizer phosphorus.

ACKNOWLEDGMENTS

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FUSARIUM STORAGE ROT OF POTATOES IN PRINCE EDWARD ISLAND[1]

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ABSTRACT

Isolations from soil and from decayed tubers have shown that *Fusarium sambucinum* f. 6 is the chief cause of storage rot of potatoes in Prince Edward Island.

Storage rot caused by *F. avenaceum* and *F. coeruleum* has been encountered in a few instances.

Cultural biotypes of *F. sambucinum* f. 6 were found to differ pathogenically but not to a degree that would impair comparisons of varietal susceptibility using random isolates of the fungus as inoculum.

INTRODUCTION

Fusarium storage rot of potatoes has been observed for many years in potatoes grown in Prince Edward Island. The severity of the disease has, however, increased sharply during the last ten years concomitantly with the widespread commercial adoption of the variety Sebago and the decline in acreage of the variety Irish Cobbler. Losses from this disease reached a peak in the 1946 and 1947 crops. Some stock developed as high as 40 per cent rot and a great many growers suffered losses of 5 to 10 per cent. Since that time the disease incidence has been less, but severe rot often occurs especially in stock that is held in storage for several months.

Fusarium rot of potatoes has been studied in Great Britain (6, 7, 8, 9, 11, 12, 14), the United States (3, 4), New Zealand (1), Finland (13), Algeria (2) and France (10). Most investigations have shown that fungal elements present in the soil are the causal agents and that rot is initiated in wounds contracted during the harvesting and grading of the crop. Infection occurring in Prince Edward Island has also been found to originate in this manner, and it has been observed that the greatest degree of tuber injury takes place during digging operations. Numerous small bruises incurred at this time provide excellent infection courts for inoculum present in the soil.

Several species of the genus *Fusarium* have been shown to cause tuber decay but *F. coeruleum* (Lib.) Sacc. has been reported as the predominating causal organism in all places except New York State where Cassell (3) reports *F. sambucinum* f. 6 Wr. as the chief pathogen. In Long Island, Cunningham and Reinking (4) report *F. coeruleum* and *F. sambucinum* f. 6 as the causal agents of severe seed-piece decay. In Prince Edward Island the species of *Fusarium* associated with storage rot have never caused serious seed-piece decay.

CAUSAL ORGANISMS

Numerous samples of dry rot in tubers were examined during the period 1947-1952, and in nearly all cases the pathogen was found to be

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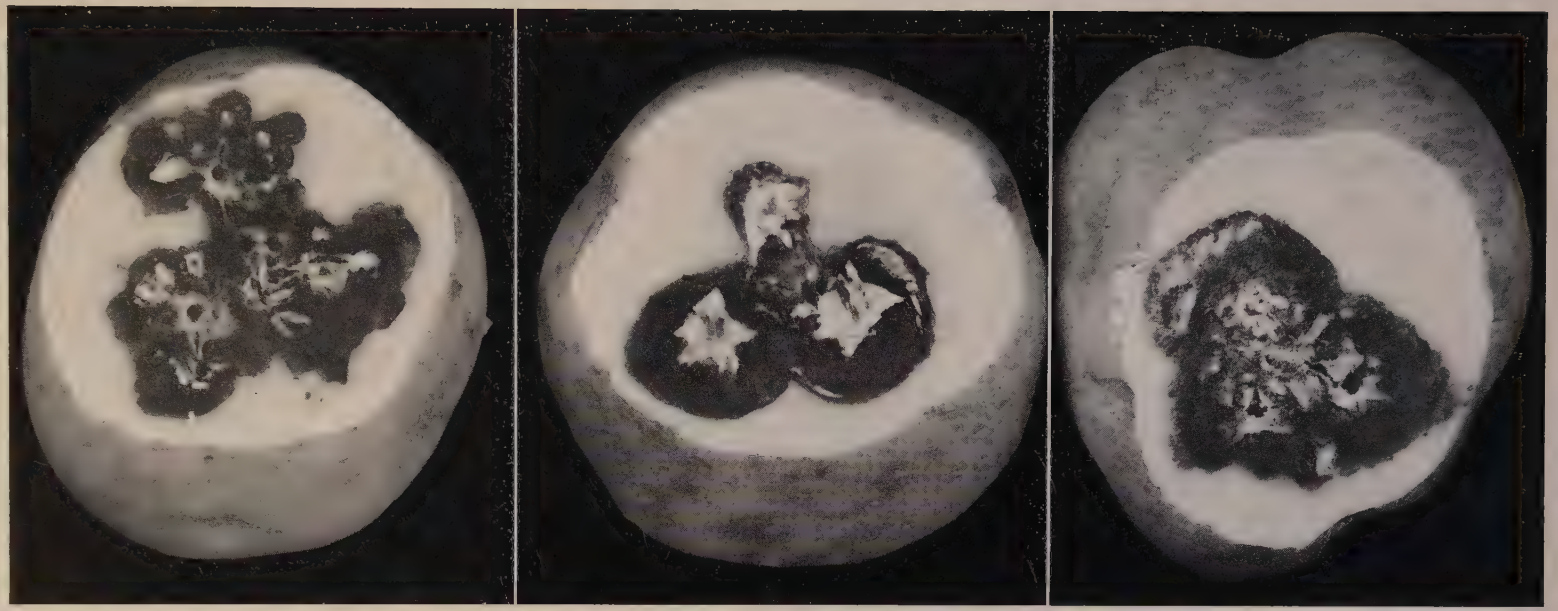

FIGURE 1. Typical appearance of rot produced by three species of *Fusarium*. *Left—F. sambucinum* f. 6, variety Sebago; *centre—F. avenaceum*, variety Sebago; *right—F. coeruleum*, unnamed variety No. 424. Note the abundant mycelium in tissue invaded by *F. sambucinum* f. 6 and *F. avenaceum*.

F. sambucinum f. 6. In a few minor instances rot was found to be caused by *F. coeruleum* and *F. avenaceum.*

SYMPTOMS

Tuber decay caused by species of *Fusarium* does not advance rapidly under normal temperatures for potato storage, and many infected tubers may escape detection till late in the storage season. Infection by *F. sambucinum* f. 6 may be indicated first as a clearly visible shrinkage and darkening of a portion of the tuber, or the disease may progress toward the centre of the tuber and serious decay may occur before rot is observed. Diseased tuber tissue may be light to deep brown, and dry to slightly moist, depending on the variety of potatoes affected. Cavities containing white mycelium form in such rotted tissue. The cavity walls are frequently tinted pink because of the presence of spore masses.

Decay caused by *F. coeruleum* is quite similar to that caused by *F. sambucinum* f. 6. Varietal susceptibility trials, however, have shown that rot caused by *F. coeruleum* is always light brown and cavity walls are usually tinted blue because of heavy sporulation of the fungus.

Tuber invasion by *F. avenaceum* produces a black decay with clearly defined edges. White mycelium is abundant in cavities formed in the invaded tissue.

THE OCCURRENCE OF DRY ROT FUSARIA IN PRINCE EDWARD ISLAND SOILS

As storage rot originates from spores or mycelium present in the soil it was reasoned that the severity of rot found in stock grown in different fields would be strongly influenced by the relative degree of soil infestation. Accordingly 133 soil samples were collected at random and tested for the presence of species of *Fusarium* causing storage rot. Tubers of the Sebago variety, first washed and sterilized in a 2 per cent formalin dip, were used as culture media, and exposure to possible infection was achieved by immersion of wounded tubers in a water suspension of soil. Tubers were wounded by standardized puncturing at two points in each tuber and constant amounts of soil and water were used for each source. Forty to 400 tubers were used for each sample, depending on the availability of host material, and the inoculations were performed in three series of experiments with suitable checks of sterilized soil. Following inoculation all tubers were stored in new jute bags at 40°-60° F. till storage rot was clearly apparent in one or more lots.

Between 1.7 and 5 per cent storage rot developed in all check lots although in each series some inoculated lots showed no rot. In the appraisal of results no significance was attached to the occurrence of rot in amounts of 10 per cent or less. Approximately one-third of all soil samples tested produced decay in excess of 10 per cent, while one-eighth of the soils caused over 30 per cent rot.

The use of tubers as isolation media has shown that *F. sambucinum* f. 6 is a common soil inhabitant and the cause of practically all Fusarium storage rot occurring in representative soils tested. *F. avenaceum and F. coeruleum* were the pathogens in a few instances but these organisms are of no economic importance as causes of storage rot in Prince Edward Island.

VARIATION IN *F. SAMBUCINUM* f. 6 ISOLATES

In the course of determining the relative infestation of soil samples, and in the examination of commercial tuber stocks, isolates of the predominating organism, *F. sambucinum* f. 6, fell into one of three biotypes distinguishable by size of spore and cultural appearance on 2 per cent potato dextrose agar. These mass isolates were cultured by monospore methods. The monoconidial cultures were then inoculated into, and re-isolated from, Sebago tubers and were found to remain relatively constant for these morphological characters (Table 1).

TABLE 1.—CULTURAL APPEARANCE AND LENGTH OF CONIDIA OF THREE BIOTYPES OF *F. sambucinum* f. 6 GROWN ON 2 PER CENT POTATO DEXTROSE AGAR

Biotype	Cultural appearance	Length of spores (microns)*	
		Before inoculation (monospore culture)	After inoculations (mass isolate)
A	Dense masses of salmon-pink spores with sparse white aerial mycelium	22.38 ± 0.57	22.61 ± 0.53
B	Dense masses of bright orange spores with sparse white aerial mycelium	24.18 ± 0.66	27.56 ± 0.05
C	Sparse production of salmon pink spores with moderate to abundant white aerial mycelium	19.20 ± 0.64	19.87 ± 0.49

* Spore length given as the mean of 50 measurements together with the standard error of the mean.

A comparison of the standard errors of measurement differences shows that the fungus biotypes are significantly different in length of conidia and that these differences remain relatively constant after inoculation into, and re-isolation from, Sebago tubers.

It is noteworthy that *F. coeruleum* and *F. avenaceum* both have greater spore length than *F. sambucinum* f. 6. The average of 50 measurements of *F. coeruleum* spores was 31.80 ± 0.46 and for *F. avenaceum* 39.93 ± 1.89.

The three biotypes of *F. sambucinum* f. 6 were tested for relative pathogenicity on two potato varieties (Irish Cobbler and Sebago) which had in previous tests shown a marked difference in susceptibility to storage rot. No method was available for accurately controlling the spore load of each respective biotype during inoculation, and thus differences were not tested directly because of the possible effect of spore load on varietal susceptibility. Instead, the significance of the statistical interaction "varieties × biotypes" was used as a measure of relative biotype pathogenicity as this variate would be independent of any differences in the spore suspensions used.

Lots of 25 tubers of each variety were thoroughly washed, wounded by puncturing at two points in each tuber, then immersed in heavy spore suspensions. The test was performed as a four-replicated split-plot randomized block experiment with varieties as sub-plots. Following inoculation all tuber lots were stored at 60° F. for three weeks, then

examined by slicing at right angles to the wounds. A "rot index" was calculated for each treatment by giving each storage rot lesion a rating of zero to six to indicate the extent of infection, then converting the total of these ratings to a percentage as follows:

$$\text{Rot index} = \frac{\text{Totals of ratings}}{\text{possible } (50 \times 6)} \times 100$$

These "rot-index" data are given in Table 2.

TABLE 2.—THE RELATIVE PATHOGENICITY OF THREE BIOTYPES OF *F. sambucinum* f. 6 ON THE VARIETIES IRISH COBBLER AND SEBAGO

Variety	Average rot index*		
	Biotype A	Biotype B	Biotype C
Irish Cobbler	9.5	10.5	11.1
Sebago	42.6	47.8	38.2
Necessary difference for significance	$\frac{\text{variety} \times \text{biotype}}{P = 0.05} = 5.5$		

* Angle transformation of percentage data as given by Snedecor (17).

A study of "variety × biotype" interactions in Table 2 shows an interaction difference of 10.2 for B and C (47.8-38.2) − (10.5 − 11.1), and 6.0 for A and C (11.1 − 9.5) − (38.2-42.6). These differences are greater than the necessary difference for significance of 5.5, and so these pairs of biotypes have a significantly reverse reaction on the two varieties and may therefore be considered pathogenically different with respect to them.

CONTROL STUDIES

Numerous attempts were made to control storage rot by chemical methods and by harvesting and storing potatoes under varied environmental conditions. Some success in chemical control has been achieved in Great Britain by dusting newly dug potatoes with a derivative of tetrachloronitrobenzene (18), with thymol (5), and with the organic mercury compound "aretan" (15). This control has been achieved in each case with relation to infection by *F. coeruleum*.

Efforts were made to control storage rot in both commercial and experimental lots of tubers by dusting with "Fusarex", a commercial preparation in which the active ingredient is a derivative of tetrachloronitrobenzene. The dust was applied at the rate of 10 lb. per ton of potatoes immediately after they had been harvested from soils that were known to be infected with *F. sambucinum* f. 6. Large quantities of tubers (from 2 to

5 tons) were used in each test. This treatment, however, proved entirely ineffective in preventing decay by this storage rot organism.

Preliminary tests with thymol gave some control of rot but this chemical was found to cause a breakdown of the surface tuber tissue and studies were discontinued.

DISCUSSION

These investigations have shown that *F. sambucinum* f. 6, and to a much lesser extent *F. avenaceum* and *F. coeruleum*, are responsible for storage rot of potatoes in Prince Edward Island. When the varieties Irish Cobbler and Sebago were used as differential hosts some significant differences in pathogenicity could be shown to exist among three biotypes of *F. sambucinum* f. 6. These differences, however, were not great enough to change the relative susceptibility of the two varieties. Irish Cobbler tubers always showed much greater resistance to storage rot than Sebago tubers.

The relative stability of varietal reaction to the biotypes of *F. sambucinum* f. 6 and the finding that most mass isolates conform to the type designated as "A" afford a sound basis for varietal susceptibility trials, using mass isolates of the fungus as inoculum.

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DEVELOPMENTS IN THE CHEMICAL CONTROL OF BLACK FLIES (DIPTERA : SIMULIIDAE)[1]

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ABSTRACT

Various formulations of TDE, schradan, dieldrin, heptachlor, DDT, and three experimental compounds were tested against larvae and pupae of *Simulium venustum* Say in streams near Churchill, Manitoba. Formulations of schradan, dieldrin, heptachlor, and the experimental compounds were tested against eggs and pupae of the same species in the laboratory.

Heptachlor suspensions gave excellent control of black-fly larvae at dosages down to 0.5 p.p.m.-minutes, one-third of the required dosage of DDT. No other material was effective against larvae at dosages lower than that required with DDT. A formulation of DDT suitable for dropping into streams from a helicopter is described. None of the materials was more promising against eggs or pupae than gamma BHC and parathion.

The hypothesis is advanced that, at least in permafrost areas, no special measures need be taken for black-fly control where DDT applications for any purpose are made at a rate in pounds per acre per annum greater than 0.012 times the annual precipitation in inches.

INTRODUCTION

No materials yet reported on as black-fly larvicides have satisfactory toxicity to eggs or pupae (1, 2); neither have formulations of DDT suitable for the widespread treatment of small streams from a helicopter been reported. This method of application is the most promising for routine control in many areas (3). In an attempt to find preparations to satisfy these needs twelve preparations were tested near Churchill, Manitoba, in 1951 and 1952.

MATERIALS AND METHODS

The following materials were tested:—

TDE (DDD or Rhothane)

An oil solution containing 30 per cent of the technical compound. Applied after dilution to 10 per cent with fuel oil.

An emulsion prepared by shaking 150 cc. of the oil solution with 12 gm. of sodium lauryl sulphate, and adding water to make 750 cc.

Malathon (American Cyanamid Company's Experimental Compound 4049)

A wettable powder containing 25 per cent of an organic phosphorus compound as active ingredient. Applied as a suspension containing 40 gm. of active ingredient per litre.

Emulsifiable liquid E. 20 containing 50.3 per cent of the same active ingredient. Applied after diluting 50 cc. to 1 litre with water.

[1] Contribution No. 3069, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada; in co-operation with the Defence Research Board.

[2] Entomologist in the seasonal employ of the Veterinary and Medical Entomology Unit, Division of Entomology, and Associate Professor of Entomology, University of Alberta.

Schradan

Dow Chemical Co. formulation C-1014, containing 63.3 per cent of technical grade octamethylpyrophosphoramide. Applied after diluting 100 cc. to 1 litre with water.

Endrin (*Julius Hyman's Experimental Compound 269*)

An emulsion concentrate containing 18.5 per cent of active ingredient. Applied after diluting 100 cc. to 1 litre with water.

Isodrin (*Julius Hyman's Experimental Compound 711*)

An emulsion concentrate containing 18.5 per cent of active ingredient. Applied after diluting 100 cc. to 1 litre with water.

Dieldrin

A preparation supplied by the Reasor-Hill Corporation containing 5 per cent of dieldrin in bentonite granules. Applied in this form.

Heptachlor

A wettable powder containing 25 per cent of active material, supplied by the Velsicol Corporation. Applied as suspensions containing from 10 to 100 gm. of active material per litre.

DDT

Excelsior "sausages" prepared by soaking cheesecloth tubes 2 inches in diameter stuffed with excelsior to a weight of 10 gm. per foot, in a 27 per cent solution of technical DDT in xylene. Applied after allowing the xylene to evaporate, and tying the tube at 9-inch intervals. Each sausage contained 2.55 gm. of DDT, that is, sufficient to treat 1 cusec (cubic foot per second) of water at 1.5 parts per million-minutes.

Similar sausages in which the DDT was applied from solution in 1/1 and 2/8 mixtures of xylene and fuel oil (referred to in Table 1 as sausages 2 and 3, respectively). After soaking and draining, these sausages were kept in closed containers to prevent the evaporation of the solvents.

Cakes of sawdust bound with a water soluble wax (Carbide and Chemical Company's Carbowax 6000) containing 10 gm. of DDT per cake in the form of 25 per cent emulsion concentrate, and with a string embedded for attachment in the stream (referred to in Table 1 as "chuckers"). Formulation and material provided by L. C. Curtis, Veterinary and Medical Entomology Section, Laboratory of Entomology, Kamloops, B.C.

The methods of test were those already described (1, 2). All applications to streams, except those of the DDT and dieldrin formulations, were made either from a graduate or from an eye dropper. Each application was continued over a period of 15 minutes, so that the concentration of insecticide in the stream water in each test is obtained by dividing the dosage in p.p.m.-minutes (Table 1) by 15. The method used for ovicide experiments in 1949 was also used for laboratory tests of some materials against eggs and pupae in 1951 and 1952. Whenever possible, treated and untreated pupal samples were taken from streams in which new toxicants were tested, to provide a check on the laboratory tests against pupae.

TABLE 1.—RESULTS OF STREAM TESTS OF INSECTICIDES AGAINST BLACK-FLY LARVAE AND PUPAE, CHURCHILL, MAN., 1951 AND 1952

Date	Stream length observed	Flow	Temperature	Insecticide formulation	Dosage	Reduction in larval population	Percentage emergence from pupal samples	
							Check	Treated
	yards	cusecs	°F.		p.p.m.-min.			
June 22/51	800	1.26	60	DDT "sausage" 1	2.8	Moderate	—	—
June 27/51	400	2.24	51	TDE oil solution	1.5	Moderate	63	69
June 27/51	600	0.395	51	TDE oil solution	1.5	Moderate	100	82
June 27/51	300	0.56	51	TDE oil solution	0.3	Slight	97	83
July 7/51	500	0.43	67	DDT "sausage" 2	1.5	Excellent	—	—
July 8/51	300	0.73	61	Schradan	6.0	Nil	77	73
July 9/51	800	0.55	56	Malathon emulsion	6.0	Slight	75	81
July 9/51	500	1.12	62	TDE emulsion	6.4	Good	92	100
July 10/51	1500	3.2	64	Malathon suspension	6.0	Nil	—	—

TABLE 1.—RESULTS OF STREAM TESTS OF INSECTICIDES AGAINST BLACK-FLY LARVAE AND PUPAE, CHURCHILL, MAN., 1951 AND 1952—*Concluded*

Date	Stream length observed	Flow	Temperature	Insecticide formulation	Dosage	Reduction in larval population	Percentage emergence from pupal samples	
							Check	Treated
	yards	cusecs	°F.		p.p.m.-min.			
June 9/52	300	1.94	40	DDT "chucker"	1.5	Moderate	—	78
June 10/52	300	0.4	44	Endrin emulsion	3.0	Nil	—	—
June 12/52	900	4.16	51	Endrin emulsion	6.0	Nil	80	85
June 12/52	400	3.1	53	DDT "chucker"	1.9	Slight	—	—
June 14/52	900	4.1	43	DDT "sausage" 3	1.5	Excellent	100	93
June 14/52	400	0.66	44	DDT "sausage" 3	1.5	Excellent	77	65
June 16/52	300	0.46	55	Dieldrin bentonite	6.5	Excellent	71	93
June 16/52	300	3.6	60	Dieldrin bentonite	3.0	Good	100	97
June 18/52	200	22.4	58	Isodrin emulsion	4.6	Slight	97	100
June 18/52	200	17.8	58	Isodrin emulsion	3.3	Nil	100	77
June 21/52	500	1.79	60	Heptachlor suspension	3.0	Excellent	—	100
June 23/52	300	0.81	61	Heptachlor suspension	1.5	Excellent	—	100
June 24/52	200	0.78	61	Heptachlor suspension	0.5	Excellent	88	83
June 26/52	400	0.7	60	Heptachlor suspension	0.15	Moderate	100	78

In nearly all tests *Simulium venustum* Say was the dominant species. Next in abundance was *Eusimulium furculatum* Shewell; small numbers of *E. latipes* (Mgn.) and *Cnephia mutata* Mall. were present in some streams.

Screens to sample the organisms killed were fixed in all streams in which a material was tested for the first time.

In laboratory tests, the eggs were of *S. venustum*, and less than 1 per cent of the pupae belonged to species other than *S. venustum*.

RESULTS AND DISCUSSION

The results obtained in stream tests are summarized in Table 1. When no living larvae could be discovered in the observed length of stream after treatment, this was recorded as excellent control; control was recorded as nil if no change in the population could be detected. If scattered larvae were found throughout the observed length, or if the distance for which the larvae were eliminated or killed was less than the observed length, control was classed as slight, moderate, or good, according to the degree of infestation remaining in comparison with the initial population. Treatments were assessed as nearly as possible 24 hours after application. Assessments were repeated 48 hours after application unless excellent control was found after 24 hours.

The same insect orders were represented in the screen samples from heptachlor- and from DDT-treated streams, in similar proportions. None of the other samples showed striking differences. The samples all contained a much smaller number of species than those obtained in 1947 and 1948.

In the laboratory tests against eggs, no mortality was caused by schradan or malathon emulsion at any dosage up to the maximum tested, which was 20.0 p.p.m.-minutes. Endrin, isodrin, dieldrin, and heptachlor reduced the mean percentage hatch from 96 to 75, 83, 74, and 67, respectively at a dosage of 6.0 p.p.m.-minutes. Mortality at 1.5 p.p.m.-minutes was negligible. All tests were run at temperatures from 60° to 63° F.

In the tests against pupae, schradan caused no reduction in emergence at dosages up to 25.0 p.p.m.-minutes; malathon emulsion was equally ineffective at dosages up to 10.0 p.p.m.-minutes. All tests were run at 52° F.

No explanation can be offered for the partial failure of DDT "chuckers"; these disintegrated completely within the 24-hour observation period. The earlier "sausages" apparently failed because the DDT was not transferred to the water rapidly enough; in spite of the loose texture, much of it could still be seen in the sausage after 48 hours. Even the later sausages were slower than DDT formulations tested hitherto; after 24 hours oil was still evident in the sausages and a few living larvae remained. Dieldrin-bentonite granules gave better results than any previously tested formulation of this material. Disintegration appears slow enough to permit helicopter application. Better results were expected with TDE, which Lindquist and Roth (4) found extremely toxic to the Clear Lake gnat; it appears to be a possible substitute for DDT, but only at a much higher

dosage. Heptachlor may prove a useful alternative to DDT. A striking feature of its use is that many larvae are killed before they release, and remain attached to the rocks and vegetation.

No material, either in the laboratory or in the field, proved more toxic to pupae or eggs than gamma BHC or parathion.

Many streams in the vicinity of the army camp at Churchill that had been used for tests of black-fly larvicides in 1947 and 1948, and were then heavily infested, contained few if any larvae at the time of the investigations now reported. It was suspected that this was because small amounts of DDT from previous aerial and ground applications for mosquito control were continually finding their way into the streams in surface drainage water. Accordingly, thorough surveys of all streams in the vicinity of the camp were made early in July and in the middle of August, 1952. These surveys confirmed that streams draining from the camp area were relatively free of larvae, whereas others flowing close to them, but draining unsprayed areas, supported abundant populations.

An important fraction of any DDT applied as an aerial or ground spray must, particularly in permafrost areas, ultimately pass into run-off water. The concentration of DDT in streams draining a sprayed area will depend on the size of this fraction, the amount of DDT applied, and the amount of precipitation. If it is assumed that the fraction of the DDT passing into the streams is one-tenth, the minimum annual application for mosquito control of 0.2 lb. of DDT per acre would give at Churchill, with an average annual precipitation of 16.84 in., a continuous concentration of at least 0.005 p.p.m. in the streams draining a sprayed area. A black-fly larva exposed to this for its normal developmental period of about 3 weeks would received a dosage of 15.1 p.p.m.-minutes ($0.005 \times 21 \times 24 \times 60$). Though it is not to be expected that the hyperbolic relationship between time and concentration would hold precisely at such extreme dilutions, there is sufficient margin between this dosage and the recommended application of 1.5 p.p.m.-minutes to justify the hypothesis that the absence of black-fly larvae from streams draining the camp area is explicable in terms of the probable concentration of DDT in the streams.

Under similar conditions, the amount of DDT appearing in the streams will be closely related tc the ratio of the weight applied per acre to the annual precipitation, in this case, expressing these quantities in customary units, about 0.012 to 1. It may be further suggested then, that at least in permafrost areas, no special measures need be taken for black-fly control where DDT applications for any purpose are made at an average rate in pounds per acre per annum which exceeds 0.012 times the annual precipitation in inches. Possibly a very much smaller ratio of DDT applications to rainfall would suffice. Travis *et al.* (5), for example, obtained control of other black-fly species in the Adirondacks with an average rate, applied as spaced swaths, of about 0.0084 lb. per acre, i.e., about 0.00018 times the annual precipitation in inches there.

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REMOVAL OF ORGANIC MATTER WITH SODIUM HYPOBROMITE FOR PARTICLE-SIZE ANALYSIS OF SOILS[1]

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ABSTRACT

The relative effectiveness of sodium hypobromite (NaOBr) digestion was compared to hydrogen peroxide (H_2O_2) digestion with and without acetic acid for the removal of organic matter from non-calcareous and calcareous soils in preparation for particle-size analysis. The dispersion obtained on four soils following NaOBr digestion was compared to the dispersion obtained following H_2O_2 digestion with and without subsequent boiling in 2 per cent Na_2CO_3 solution.

It was found that NaOBr digestion does not destroy calcium or magnesium carbonates and is as effective as H_2O_2 digestion in the dispersion procedure for particle-size analysis. The carbonates remaining in soil following NaOBr digestion resided in the 5- to 50-micron fraction. The H_2O_2 digestion involving acid treatment is recommended as the most suitable procedure, except when the destruction of the calcium and magnesium carbonates is to be avoided. Dispersion of the clay fraction obtained following NaOBr digestion is comparable to that obtained following H_2O_2 digestion. However, with one calcareous soil, NaOBr digestion and boiling the soil in Na_2CO_3 following H_2O_2 digestion gave better clay dispersion than was found with H_2O_2 digestion alone.

A complete dispersion of soil aggregates during particle-size distribution analysis cannot be accomplished unless the soil organic matter is removed. Although hydrogen peroxide (H_2O_2) effectively digests organic matter in acid soils, suitable H_2O_2 digestion of calcareous soils requires acid additions during digestion and the acid destroys calcium carbonates. Therefore, H_2O_2 digestion cannot be used conveniently for removing organic matter from soils in which destruction of the carbonates is to be avoided. Sodium hypobromite (NaOBr) is an alkaline oxidant that may be used to remove organic matter from calcareous soils without destroying the carbonates. The objective of the investigations reported was to compare the relative effectiveness of NaOBr with H_2O_2 for the digestion of organic matter, and to compare the dispersion obtained on four soils following NaOBr digestion to that obtained following H_2O_2 digestion.

REVIEW OF LITERATURE

Both H_2O_2 and NaOBr have been used as oxidants of soil organic matter for particle-size distribution analysis. During the development of techniques for organic matter digestion, the use of H_2O_2 has steadily increased and it is now the most commonly used method.

Need of Acid for H_2O_2 Digestion of Organic Matter

McLean (6) and Hoskins (4) found that digestion by H_2O_2 of the organic matter in calcareous soils was less effective than in acid soils.

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Scharrer (10) treated alkaline and acid soils with acid-free H_2O_2 and reported that the rate of oxygen evolution was greater with alkaline soils than with strongly acid soils. There was no indication that the effectiveness of oxidation increased with increasing rates of oxygen evolution. Where the oxygen evolution from H_2O_2 is too violent to be efficient, Truog *et al.* (13) suggested acidifying the H_2O_2 solution by adding concentrated HCl at the rate of 1 drop per 1000 ml. of H_2O_2. Piper (9) found that the dispersion of soils increased when their organic matter was removed by the H_2O_2 involving acid treatment. Olmstead, Alexander, and Middleton (7) suggested the use of acetic acid with the H_2O_2 to help overcome the reaction of MnO_2 with H_2O_2. The literature emphasizes that the use of acid with H_2O_2 aids in organic matter oxidation in both calcareous and manganiferous soils.

Sodium Hypobromite Digestion of Soil Organic Matter

Atterberg (2) and Troell (12) have suggested the use of alkaline NaOBr for the oxidation of soil organic matter and the importance of using a freshly prepared solution has been noted (8, 12). The NaOBr (12) was prepared from elemental Br which was safely reacted with NaOH. Because of the danger of contact with bromine fumes this method requires great care but to overcome this difficulty, Arias (1) and Vergez (14) have described methods of preparing NaOBr from salts of bromine.

PROCEDURE

The research reported was conducted on both non-calcareous and calcareous soils including Miami silt loam, Onamia loam, Reliance silty clay and Presho silty clay. Parr silt loam, to which various amounts of calcium carbonate had been added, was used also to compare digestion treatments. All soils were sieved through a 2-mm. sieve using finger pressure only. Triplicate samples were used for all comparisons.

The relative effectiveness of H_2O_2 and NaOBr in removing organic matter from calcareous and non-calcareous soils which contained various amounts of organic matter was compared by the loss from digestion (organic matter and soluble salts). The organic matter contents of the soils were also determined by the chromic acid oxidation (11).

The soil dispersion achieved following the two digestion methods was measured by the particle-size distribution analyses when three dispersion procedures were used. The dispersion procedures, given in detail below, were: (*a*) NaOBr digestion, (*b*) H_2O_2 digestion and (*c*) H_2O_2 digestion and boiling with Na_2CO_3. Samples were not allowed to dry at any time during the digestion in order to avoid any effect that drying may have on the dispersion of the clay fraction. The loss from digestion was determined on a separate sample. Following the organic matter digestion the samples were washed free from soluble salts with an alundum filter. The soil was dispersed with 20 ml. of 0.3 N sodium hexametaphosphate $(NaPO_3)_6$ containing 1.22 gm. of sodium carbonate per litre, and the suspension was shaken for 8 to 10 hours. After dispersion, the sand was separated from the silt and clay by washing the dispersed sample through a 300-mesh sieve. The sand fractions were obtained by dry sieving.

The 20-, 5-, 2-, and 1-micron fraction were obtained by pipetting. The suspension of clay and silt that passed through the 0.05-mm. sieve by wet sieving was transferred up a litre cylinder. The cylinders were placed into a controlled temperature bath at 40.0 ± 0.05° C. and made to one litre. The suspension was stirred and pipette samples were taken at appropriate times with a Lowy pipette which was filled in 12 seconds. A weight correction was made for the dispersing agent added. Particle diameters were calculated from Stokes' Law for acceleration of gravity.

The fraction less than 0.2-micron was obtained by repeated decantation using an International No. 2 centrifuge. The sedimentation time was calculated from the Stokes' equation for the centrifuge. The decanted suspension containing particles less than 0.2 microns was flocculated with NaCl and freed from soluble salts by simple dialysis. No correction was required for dispersing agent.

Sodium Hypobromite Digestion

Preliminary tests were run to find a suitable way to prepare the NaOBr reagent. The following method proved the most satisfactory and was chosen for this research. A volume of 180 ml. of 3N KBr was reacted with 180 ml. of 3 N $KBrO_3$ and 10 per cent H_2SO_4 to give Br_2 in accordance with the equation below. Then 600 ml. of 2 N NaOH were added giving 960 ml. of 0.313 N NaOBr and 0.687 N NaOH. The resulting solution was filtered with ordinary funnel and filter paper:

$$KBrO_3 + 5KBr + 3H_2SO_4 \longrightarrow 3Br_2 + 3H_2O + 3K_2SO_4$$

$$Br_2 + 2NaOH \longrightarrow NaOBr + NaBr + H_2O$$

A 20-gm. air-dried sample of sieved soil was placed in a 600-ml. beaker and treated with 100 ml. of the freshly prepared NaOBr. The reaction was allowed to continue at room temperature for two hours. The suspension then was heated on a hot plate, but was not boiled in order to avoid loss of bromine fumes. A second increment of 200 ml. of the NaOBr was added to the hot suspension, the mixture was vigorously stirred, and allowed to stand over-night without further heating.

Hydrogen Peroxide Digestion

A 20-gm. air-dry sample of sieved soil was weighed into a 400-ml. beaker fitted with a cover glass. One ml. of glacial acetic acid was pipetted into the beaker. Five ml. of 35 per cent H_2O_2 solution were added to the soil in the beaker. The mixture was stirred and watched closely until the reaction was completed. Increment of 5 ml. H_2O_2 were added up to 20 ml. Further additions of acetic acid were used as required to prevent violent H_2O_2 reaction. If 20 ml. of H_2O_2 were not sufficient, more was added. The sample was then heated on a hot plate of 100°-110° C. until the digestion was complete.

Sodium Carbonate Boiling

In one dispersion procedure, the H_2O_2-treated sample was boiled with Na_2CO_3 (5) to attain alkaline dispersion comparable to that with NaOBr. The digested soil sample was freed from soluble salts and mixed with 150 ml. of 2 per cent Na_2CO_3 solution. The suspension was covered with watch glass and boiled for 5 to 10 minutes. Excess Na_2CO_3 was then washed out.

RESULTS AND DISCUSSION

The organic matter and soluble salts losses of the Parr silt loam soils following six different methods of organic matter digestion are reported in Table 1. The disagreement between the chromic acid results and the losses from digestion with either NaOBr and H_2O_2 is noticeable. However, the chromic acid procedure and factors may be in error to some extent. Even though NaOBr and H_2O_2 digestion losses disagree with the chromic acid results, organic matter digestion is necessary to prepare most soils for particle-size analysis and the principal purpose here is to compare NaOBr and H_2O_2 digestions. The NaOBr method gave essentially as complete a digestion as the H_2O_2 plus excess acetic acid method on the non-calcareous Parr. The NaOBr gave much better results than H_2O_2 when carbonates were present. The losses of solution of the Parr to which $CaCO_3$ was added were high when one or more ml. of acetic acid were added because of the solution of calcium carbonate by acetic acid. The H_2O_2 digestion of

TABLE 1.—LOSS OF SOLUTION FOLLOWING ORGANIC MATTER DIGESTION BY SIX DIFFERENT METHODS

Digestion	Loss of solution of each soil Per cent ± s.d.		
	Parr (no $CaCO_3$)	Parr (10% $CaCO_3$)	Parr (20% $CaCO_3$)
H_2O_2 + excess acetic acid	6.35 ± 0.06	13.77 ± 0.30	20.51 ± 0.21
H_2O_2 + 1 ml. acetic acid	6.26 ± 0.11	12.04 ± 0.18	13.06 ± 0.03
H_2O_2 + 0.1 ml. acetic acid	5.45 ± 0.05	3.02 ± 0.20	2.57 ± 0.07
H_2O_2 + no acetic acid	5.48 ± 0.04	2.20 ± 0.12	1.82 ± 0.08
NaOBr	6.22 ± 0.20	5.17 ± 0.06	4.62 ± 0.05
Chromic acid oxidation	5.22 ± 0.00	4.74 ± 0.00	4.35 ± 0.00

TABLE 2.—THE ORGANIC MATTER AND SOLUBLE SALTS PERCENTAGES OF FIVE SOILS AS DETERMINED BY THREE DIGESTION METHODS

Soils	H_2O_2 and acetic acid	NaOBr	Chromic acid oxidation
	Per cent ± s.d.	Per cent ± s.d.	Per cent O.M. ± s.d
Miami silt loam	2.3 ± 0.02	2.4 ± 0.00	1.9 ± 0.05
Parr silt loam	6.4 ± 0.06	6.2 ± 0.20	5.22 ± 0.00
Onamia loam	2.7 ± 0.53	3.2 ± 0.00	3.1 ± 0.05
Reliance silty clay loam	7.1 ± 0.06	0.3 ± 0.04	0.8 ± 0.10
Presho silty clay	5.0 ± 0.06	0.2 ± 0.06	0.9 ± 0.30

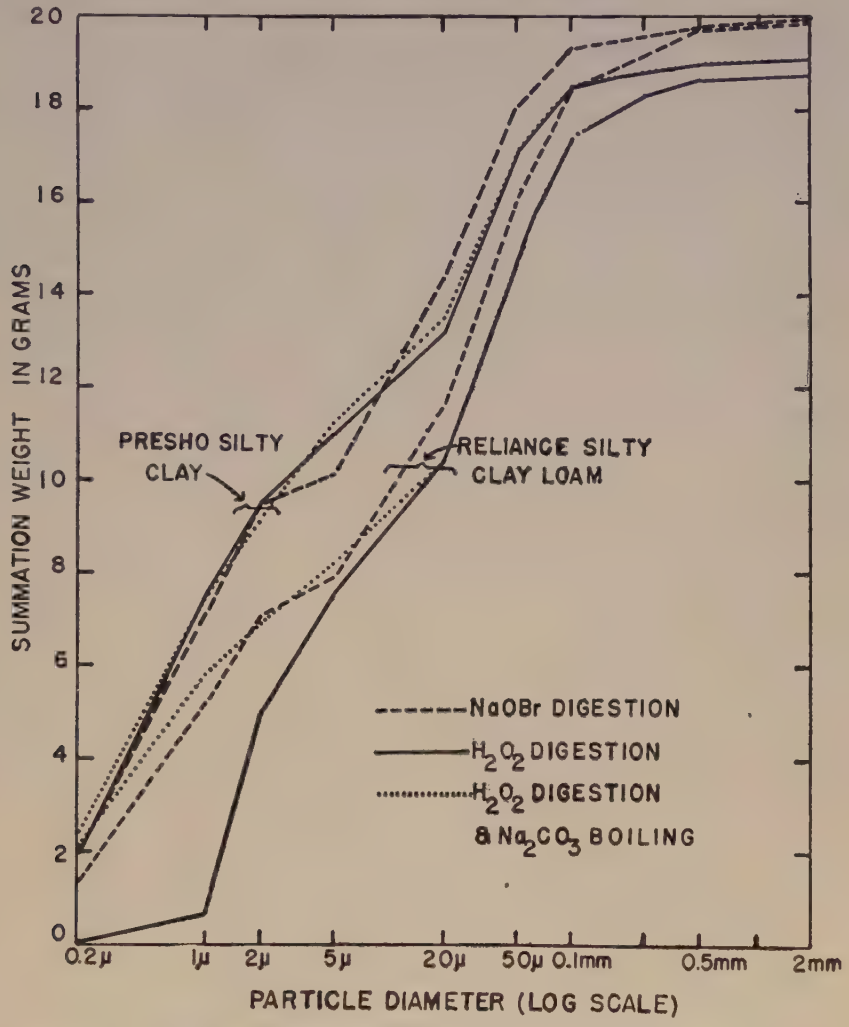

FIGURE 1. Weight summation curves of two calcareous soils from which organic matter was digested by either sodium hypobromite, hydrogen peroxide or hydrogen peroxide plus boiling in sodium carbonate.

$CaCO_3$ treated Parr with addition of 0.1 ml. or less acetic acid gave a violent but inefficient oxidation. Two or three additions of H_2O_2 per day over a period of a week or more did not produce a more efficient oxidation, and the dark colour due to organic matter still remained.

The organic matter percentages and losses by digestion of five different soils as determined by the H_2O_2 and the NaOBr digestion methods and by the chromic acid oxidation method are reported in Table 2. The percentages of organic matter and soluble salts lost from the non-calcareous Miami, Parr, and Onamia soils following the NaOBr digestion were about the same as losses following the H_2O_2 digestion. This indicates that NaOBr gives a digestion comparable to H_2O_2. Losses from the calcareous Reliance and Presho soils were much higher following the H_2O_2 than following the NaOBr

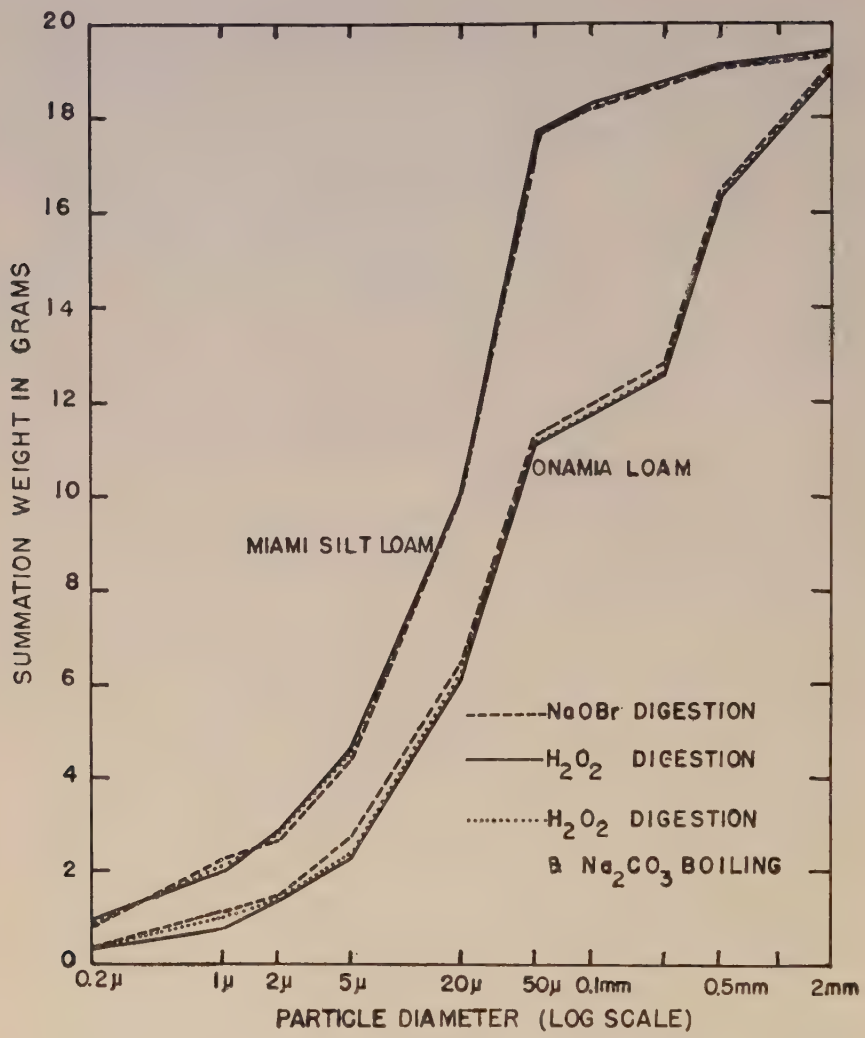

FIGURE 2. Weight summation curves of two non-calcareous soils from which organic matter was digested by either sodium hypobromite, hydrogen peroxide, or hydrogen peroxide plus boiling in sodium carbonate.

digestion, because of the solution of calcium carbonate by acetic acid during the H_2O_2 digestion. It is seen that NaOBr digestion when used with calcareous soils, does not remove calcium and magnesium carbonates. It is recognized that the two calcareous soils contained little organic matter; however, they do illustrate the applicability of NaOBr to calcareous soils.

The soil dispersion following NaOBr digestion is compared to the soil dispersion following H_2O_2 digestion in the particle-size distribution curves of Figures 1 and 2. Clay dispersion following NaOBr digestion was comparable to the dispersion following H_2O_2 digestion, except for the Reliance silty clay loam, and for that soil the dispersion following NaOBr

digestion was better. It is noted that the high NaOH concentration of the NaOBr solution did not affect significantly the clay fraction of the Miami, Onamia, and Presho soils, indicating little breakdown or solution of the soil.

The best dispersion of the fine clays in the calcareous Reliance soil was obtained by boiling the soil in Na_2CO_3 solution following H_2O_2 digestion. Though soils were not boiled in Na_2CO_3 solution following NaOBr digestion, it is noted that the clay dispersion of the Reliance silty clay loam was increased both by Na_2CO_3 boiling and by NaOBr digestion. This indicates that the basic action of these two agents gave increased dispersion. It has been demonstrated (5) that the sodium carbonate boiling treatment promoted dispersion of the aggregates in the finer fraction of soil.

The carbonates present in the two calcareous soils (Figure 1) were not destroyed by the NaOBr digestion. They resided in the 5- to 50-micron range as shown by the higher summation weights of the 20- and 50-micron fractions following NaOBr digestion. The NaOBr digestion gave a smaller summation weight at the 5-micron size for both calcareous soils. That may be explained either by a break-down of the vermiculite in the soils from a specific action of H_2O_2 (3) or by the destruction of the $CaCO_3$ cemented aggregates in the sizes range greater than 5 microns during the H_2O_2 digestion.

Since NaOBr digestion requires special reagent preparation, and results in dispersion comparable to H_2O_2 digestion followed by boiling in Na_2CO_3, the NaOBr procedure is recommended only for those soils in which destruction of the calcium and magnesium carbonates is to be avoided. Digestion with H_2O_2 is preferred for soils in which carbonates can be destroyed. Boiling in Na_2CO_3 solution is suggested following H_2O_2 digestion of calcareous soils.

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SUBSTANCES IN HERD MILKS INHIBITING ACID PRODUCTION[1]

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ABSTRACT

Of 344 samples of herd milks collected in the spring, 7.3 per cent showed inhibitory effects against lactic starter organisms, as against 5.4 per cent of of 298 summer samples. Those showing inhibitory action were then tested for the presence of antibiotics; only 1.4 per cent of the total showed zones of inhibition by the disk assay method. The marked seasonal difference between spring and summer milks observed by Cornell workers was much less evident here. The much lower percentage of positive samples by the disk assay method is attributed in part to the greater use in this area of antibiotics other than penicillin. These others are not detectable by the disk assay method at concentrations sharply inhibiting acid formation. Tests for the presence of residual quaternary ammonium compounds gave negative results, while bacteriophage action and naturally occurring heat-labile inhibitory substances were largely ruled out by preliminary heating.

INTRODUCTION

The presence in certain milk supplies of substances inhibiting the growth of starter organisms has recently become of increasing concern to the dairy industry. Apart from bacteriophage, antibiotics and sulpha drugs residual from mastitis treatment, and quaternary ammonium compounds, have been viewed with suspicion. To determine the extent to which these substances were present in pasteurized bottled milks, workers at Cornell (4, 9) examined 1794 samples from 36 counties in New York State. By the starter activity test (5), 7.8 per cent showed definite inhibition (activity < 80 per cent of control), and 6 per cent gave zones of inhibition in the disk assay test for antibiotic activity.

With blended pasteurized milks showing detectable concentrations of inhibitory substances it seemed reasonable to expect that individual herd milks would show much stronger concentrations. Consequently, a survey was undertaken to determine the degree to which herd milks in the Ottawa district contained inhibitory substances.

MATERIALS AND METHODS

A total of 642 samples of mixed morning's and night's milks was obtained in weekly batches from three Ottawa dairies (*a*) between April 17 and May 27, 1952, and (*b*) between July 24 and August 27. Duplicate 10 ml. portions were heated to 180° F. for 5 minutes to destroy natural inhibitory substances or bacteriophage (9). Starter activity was evaluated by the method, slightly modified (9), used in the Cornell studies. In place of using controls prepared from reconstituted spray powder, the acidity increase of the 10 highest samples in each batch was averaged and was given a value of 100, and all others expressed as a percentage of this value. Disk assays were conducted with *Bacillus subtilis* using the Difco assay

[1] Contribution No. 352 from the Bacteriology Division, Science Service, Department of Agriculture, Ottawa.

TABLE 1.—SUMMARY OF RESULTS OF TESTING 344 HERD MILKS FOR INHIBITORY SUBSTANCES
FIRST SERIES, APRIL–MAY 1952

Date	Dairy	No. samples	Number of samples showing								
			Starter activity (%)							Zones on disk assay	Positive on Leber activity test
			Less than 30	30–39	40–49	50–59	60–69	70–79	80 and over		
April 17	P	30	—	—	2	3	3	6	16	1	—
April 24	C	60	1	—	3	3	1	12	40	2	—
April 29	O	60	—	—	—	—	2	3	55	1	—
May 6	P	40	—	—	—	—	—	—	40	0	0
May 13	C	45	—	—	—	—	—	—	45	0	0
May 20	O	60	1	—	—	—	1	3	55	1	2
May 27	P	49	—	—	—	3	2	9	35	0	0
Total	—	344	2	—	5	9	9	33	286	5	2
Per cent	—	—	0.5	—	1.5	2.6	2.6	9.6	83.2	1.45	1.03

TABLE 2.—SUMMARY OF RESULTS OF TESTING 298 HERD MILKS FOR INHIBITORY SUBSTANCES
SECOND SERIES, JULY–AUGUST 1952

Date	Dairy	No. samples	Number of samples showing						
			Starter activity (%)						Zones on disk assay
			30–39	40–49	50–59	60–69	70–79	80 and over	
July 24	O	60	—	—	—	—	5	55	4
July 28	C	60	1	—	—	—	6	53	0
August 6	P	60	—	—	1	5	8	46	0
August 20	O	58	1	1	2	4	17	33	0
August 27	C	60	—	1	—	—	3	56	0
Total	—	298	2	2	3	9	39	243	4
Per cent	—	—	0.7	0.7	1.0	3.0	13.1	81.5	1.3

kit (9), the $\frac{1}{4}$-inch disks being wetted by dipping into the heated and cooled samples. Wherever a zone of inhibition was noted, a repeat test was run using in addition a disk containing penicillinase. Leber's modification of the resazurin test (8) for the evaluation of starter activity, using smaller inocula of starter, was also run on a number of samples. Similarly, the method for the detection of penicillin in milk recently reported by Bertelsen (1) was used in the second series.

RESULTS AND DISCUSSION

The data obtained from the first (spring) series of samples are summarized in Table 1, and those for the second (summer) series in Table 2. They show that starter activity is frequently inhibited to a greater or lesser degree, but that the percentage of samples showing the presence of antibiotics by the disk assay method is relatively small. This differs from the Cornell studies (7) where a closer relationship was found to exist between starter inhibition and the presence of antibiotics. However, only 5 of 107 Cornell samples positive for antibiotics contained over 0.1 units per ml., while 3 of the 9 positive samples in this study exceeded this value. Their practice of concentrating samples under vacuum before testing doubtless explains their higher percentage of samples showing concentrations of less than 0.1 units per ml. This procedure was not followed by the author and co-workers, it being felt that such concentrations in herd milks were of little significance.

Comparison of these results with those from Cornell might suggest a much higher percentage here of samples showing diminished starter activity. This difference, however, is more apparent than real. Kosikowsky *et al.* (7), in a paper appearing after these studies were well along, indicated that normal milks might vary $\pm$ 20 per cent in the starter activity test. They found that 48.1 per cent of the spring samples, and 56.1 per cent of the summer samples, gave values in excess of 100 per cent activity. About 6 per cent exceeded 120 per cent; this latter was attributed to the stimulatory effect of very small concentrations of antibiotic. The practice of averaging the 10 highest values for each set, and using this for a control value, makes direct comparison difficult. In the Cornell results, a value somewhere between 110 and 120 per cent appears to be comparable with the control value selected. Consequently, in the present studies, it is considered that values between 50 and 70 per cent indicate mild to medium inhibition, and under 50 per cent, strong inhibition. On this basis, the two sets of data are in reasonably good agreement.

The very much smaller seasonal differences in inhibitory milks and in positive antibiotic tests are hard to explain. As pointed out by Kosikowsky *et al.* (7), it is reasonable to expect more antibiotics in milk when cattle are stabled. Although the average values are essentially the same for both periods, all four positive tests for antibiotics in the summer series occurred in the July 24th set of samples (Table 2). With so few positive tests and so much variability, perhaps this aspect should not be emphasized.

The much smaller percentage of the inhibitory milks giving positive zones in the disk assay method with *B. subtilis* is believed to reflect the extensive use of antibiotics other than penicillin in this area. Of the nine

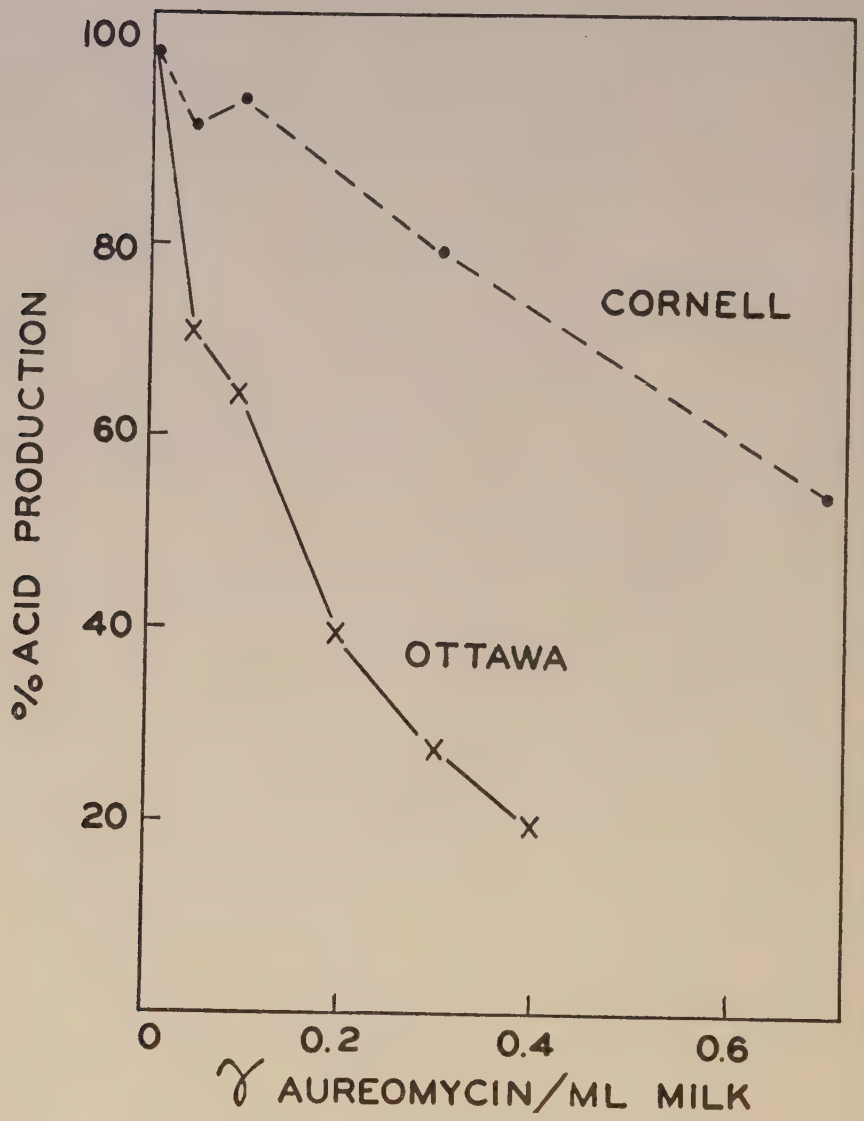

FIGURE 1. Inhibition of acid production by various concentrations of aureomycin.

milks showing zones, three were proven by the use of pencillinase disks not to contain penicillin. Furthermore, tests with addenda of known antibiotics have confirmed the Cornell findings (9) that aureomycin and dihydrostreptomycin may interfere with starter activity at concentrations well below those detectable by the disk assay method with *B. subtilis*. The minimum detectable concentration of aureomycin has been 0.2 units aureomycin/ml.; yet results from several series of tests (Figure 1) show a drastic reduction in starter activity with concentrations much lower than 0.2 units. Bradfield *et al.* (3) also reported being unable to measure less than 1 unit/ml. by bioassay although acid production was depressed by

much lower concentrations. Babel (1) also refers to partial inhibition of acid production at 0.05-0.1 units per ml. and complete inhibition when 0.5 to 1 units were present. The difference between the writer's results and those at Cornell may be due in part to differences in sensitivity of starters, although results comparable to those in Figure 1 with two different starters have been obtained. This point is being investigated.

One reason for carrying out this survey was that one dairy (C) had reported slow acid development in cottage cheese and buttermilk almost every week last winter. No reason for this being found, antibiotics residual from mastitis therapy were suspected. The incidence of mastitis in this area is unduly high, with a correspondingly heavy use of antibiotics.[1] These are freely available to farmers and are often used indiscriminately. Penicillin, while still used, is being supplanted by other antibiotics, particularly aureomycin, which is recommended for use in 400-mgm. doses.

As the starter organisms were much more susceptible to the inhibitory substances than was the test organism in the disk assay method, attempts were made to increase the sensitivity of the test by the use of the starter organisms in place of *B. subtilis*. These were unsuccessful. Similarly, unsuccessful attempts were made using *Bacillus alvei*, which Katznelson (6) has shown to be highly sensitive to aureomycin.[2]

Since treatment for mastitis is sporadic, it is not surprising that variable results should have been obtained in testing for the presence of antibiotics in milk. For example, essentially the same herds sampled on July 24 were resampled August 20, with widely different results (Table 2). The marked regional differences encountered by the Cornell workers (4) may be partially a reflection of the same thing, as well as of true regional differences in the extent to which antibiotics are employed.

The possibility that quaternary ammonium compounds used as sanitizing solutions might be responsible for the inhibition of starter organisms is considered to be slight, as they are not in common use on dairy farms in this area. Furthermore, experiments here[3] have shown that even gross carelessness is unlikely to introduce a concentration high enough to interfere with acid production. Although 4 per cent of 832 Cornell samples (7) gave a positive test for quaternaries, only 7 of 33 positive samples contained more than 3 p.p.m. In these studies a number of samples showing inhibitory effects were tested for the presence of quaternaries (9), with negative results. Sulpha drugs, now less frequently used in the treatment of mastitis, are not very inhibitory for starter organisms (9). They were not tested for in this survey, since the Cornell studies (7) failed to demonstrate their presence in any of the 920 samples tested. Bacteriophage activity may be largely ignored, since heating the milks to 180° F. for 5 minutes should suffice to prevent inhibitory action by any phage particles; nor could the inhibition always be charged to antibiotics produced by bacterial growth in the milk prior to testing, since such inhibition frequently occurred in low-count milks.

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[1] This opinion was expressed by J. M. Stevens, Officer-in-Charge, Regional Veterinary Laboratory, Ontario Department of Agriculture, Kemptville, Ont.

[2] A more sensitive disk assay method, using a selected strain of *Bacillus cereus*, has since been developed by A. C. Dornbush, Lederle Laboratories, Pearl River, N.Y.

[3] Johns, C. K. Unpublished data. 1950.

Leber's (8) resazurin test for starter activity was tried out as a simpler method of detecting inhibitory substances, but was found to be unsuitable. The inoculum of starter was reduced from 10 per cent to 0.2-0.5 per cent; otherwise reduction took place so rapidly that differences could not be noted. Even with the smaller inoculum it was rarely possible to distinguish, by slower reduction, milks showing pronounced inhibitory action by the titration method. This is difficult to understand, since the same starter culture was used in both tests and the difference in incubation temperature (98.6° vs. 92° F.) is scarcely significant. Further tests with known amounts of penicillin added to milk failed to show differences in reduction time at all comparable to those in titratable acidity.

Bertelsen (2) has recently described a test wherein heated milk after cooling is seeded with starter and incubated at not under 68° F. Absence of coagulation in 24 hours is said to indicate the presence of not less than 0.25 units penicillin/ml. To obtain an earlier indication of inhibition in our studies, resazurin was added to each tube, and the amount of starter inoculum decreased in hopes of increasing the sensitivity of the test. However, there was again poor agreement between the rates of reduction and coagulation and the titratable acidity development.

CONCLUSIONS

On the basis of these findings, it is concluded that, although individual herd milks occasionally display moderate to severe inhibitory action, it is unlikely that such milks, when pooled with normal milks, will seriously interfere with lactic fermentation. Nevertheless, there is need to impress upon producers, particularly cheese factory patrons, the necessity for withholding milk from treated quarters, since milk from a single producer is still commonly employed in preparing bulk starter. If such milk contains a measurable concentration of antibiotic, serious trouble may be anticipated.

ACKNOWLEDGMENTS

The technical assistance of J. G. Desmarais is gratefully acknowledged. Thanks are also due the local dairies who furnished the milk samples and to F. V. Kosikowsky for information concerning the Cornell studies, and for helpful suggestions in the preparation of this manuscript.

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SEED GERMINATION AND SEEDLING GROWTH AS INFLUENCED BY DIFFERENT KINDS OF SAWDUSTS[1]

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ABSTRACT

Seed germination and subsequent seedling growth of garden peas, beans, and sweet peas was greatly depressed when the seed was planted in pure cedar (*Thuja plicata*) sawdust as compared with soil, but little or no depression occurred when the seed was planted in fir (*Pseudotsuga taxifolia*), hemlock (*Tsuga heterophylla*), and balsam (*Abies grandis*) sawdusts. Balsam slightly accentuated the growth of beans and sweet peas. The incorporation of all four sawdusts at 20 per cent and 30 per cent by volume with soil depressed the germination of radish seed and subsequent seedling growth as compared with soil alone. These effects were particularly marked with cedar sawdust. Balsam sawdust caused the least and fir the greatest depression in the germination of radish seed, whereas fir sawdust caused the least and balsam the greatest depression in subsequent seedling growth. An explanation of this inverse relationship is presented.

INTRODUCTION

The practice of applying sawdust mulches to cane-fruits, strawberries, and a variety of other crops in the coastal regions of British Columbia has become quite general. Many cases of crop disease and unthriftiness have been attributed to these mulches. Field observations have indicated that cedar (*Thuja plicata*) sawdust mulches frequently exert marked toxic effects and that fir (*Pseudotsuga taxifolia*) mulches occasionally exert a stunting effect. No observational evidence has been obtained of toxic effects exerted by hemlock (*Tsuga heterophylla*) sawdust when used as a mulch.

Up to the present, no other types of sawdust have been extensively used in British Columbia as mulches. However, stunting effects have been frequently observed when either fir or hemlock sawdust is incorporated with the soil rather than used as a mulch, unless supplemented by dressings of soluble nitrogen fertilizers. The field observations are supported by little exact experimental evidence; hence an attempt has been made to obtain such.

EXPERIMENTAL

Flats were filled with freshly milled cedar, fir, hemlock, and balsam (*Abies grandis*) sawdusts. Balsam was included because there was a local supply of this sawdust. The sawdusts were moistened with tap water, and seeds of bean and sweet pea were planted in them. Other lots of the same seed were planted in flats of steam-sterilized potting soil as controls. The results as based upon the planting of 200 seeds of each kind in each sawdust are shown in Table 1.

[1] Contribution No. 1267 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

[2] Officer-in-Charge.

TABLE 1.—THE GERMINATION AND SEEDLING GROWTH OF BEANS AND SWEET PEAS IN SAWDUSTS DURING A PERIOD OF 25 DAYS

Growth medium	Percentage of beans		Percentage of sweet peas	
	Germination	Height in cm.	Germination	Height in cm.
Cedar	82	5.4	9	4.1
Fir	100	18.9	62	8.7
Hemlock	95	15.2	65	8.6
Balsam	99	21.0	75	9.5
Soil	100	17.6	72	8.4
Five per cent error	2	1.6	3	0.5

TABLE 2.—GROWTH AND GERMINATION OF GARDEN PEAS DURING A 30-DAY PERIOD IN SAWDUST MOISTENED WITH TAPWATER AND HOAGLAND'S SOLUTION

Growth medium	Percentage of water		Percentage of Hoagland's solution	
	Germination	Height in cm.	Germination	Height in cm.
Cedar	62	21	60	25
Fir	95	30	95	41
Hemlock	100	44	100	62
Balsam	100	41	100	64
Soil	100	47	100	51
Five per cent error	3	4	3	4

The germination and subsequent seedling growth of both beans and sweet peas were greatly reduced by planting in pure cedar sawdust compared with soil. The surprising feature of the results as shown in Table 1 is the greater seedling growth in pure balsam sawdust compared with soil.

In Table 2 the results are given of the effect on germination and subsequent growth of garden peas (variety Lincoln), over a 30-day period in sawdust alone and in soil as influenced by the addition of mineral nutrients.

The presence of mineral nutrients in the form of Hoagland's solution increased the total growth but did not alter the relative growth in different sawdusts. Cedar sawdust exerted a marked phytotoxic effect, fir a slightly toxic effect, and hemlock and balsam were non-toxic towards garden peas.

The influence of incorporating the sawdusts with soil upon the germination and growth of radish seed is shown by the data in Table 3. The soil and sawdust mixtures were moistened with tap water, flatted and immediately planted with radish seed (variety Sparkler), 200 seeds in each flat or in each treatment.

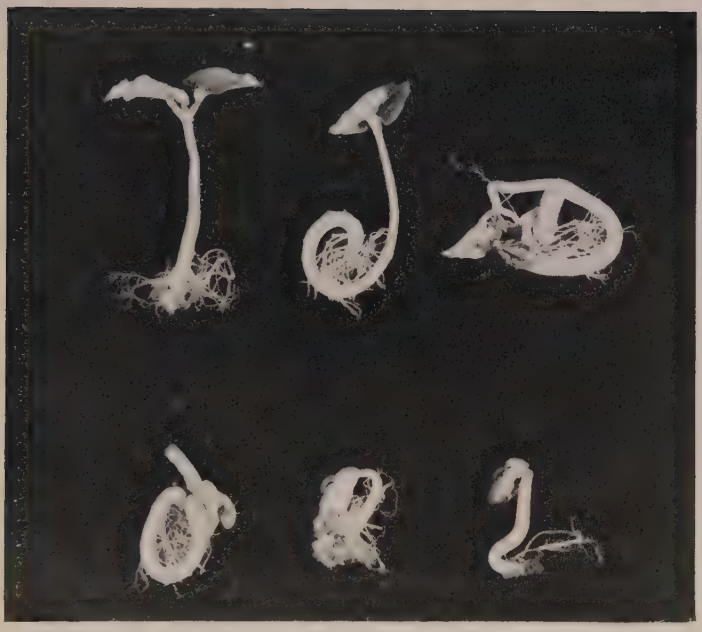

FIGURE 1. The distortion of bean seedlings as grown in soil moistened with a water extract of cedar sawdust. Upper left seedling is from an untreated soil.

FIGURE 2. The growth of sweet peas and garden beans in pure cedar sawdust (*left*) and pure balsam sawdust (*right*).

TABLE 3.—THE INFLUENCE OF MIXTURES BY VOLUME OF SAWDUSTS AND SOIL ON THE GERMINATION AND GROWTH OF RADISH SEED OVER A 28-DAY PERIOD

Mixture	Sawdust	Germination	Height in cm.
	%	%	
Cedar	10	60	51
	20	60	33
	30	62	22
Fir	10	65	54
	20	62	52
	30	64	52
Hemlock	10	75	61
	20	75	45
	30	82	39
Balsam	10	90	39
	20	95	36
	30	92	33
Soil only	—	100	60
Five per cent error	—	3	4

The data in Table 3 show that the germination of radish seed was depressed by the incorporation of all four sawdusts with soil. The germination was depressed to the greatest degree by cedar, less by fir, still less by hemlock, and least by balsam. The incorporation with soil of all four sawdusts also depressed subsequent growth at sawdust concentrations of 20 per cent and 30 per cent by volume. It will be noted that when the effects of the three sawdusts, fir, hemlock and balsam, at concentrations of 20 per cent and 30 per cent are compared, balsam exerted the least and fir the greatest depression upon the germination of radish seed and fir the least and balsam the greatest depression of subsequent growth. This inverse relationship may be explained by assuming that the depression of germination by each sawdust is a phytotoxic effect and the depression of subsequent seedling growth is a measure of the rate at which the mineral nutrients of the soil are found by the soil organisms in decomposing the sawdusts. The depression of both germination and subsequent growth by cedar sawdust would appear to be due to the very pronounced phytotoxic effect this sawdust exerts.

The toxicity of cedar sawdust was further demonstrated by adding water extracts to potting soil prior to planting with garden peas. These extracts were prepared by heating to 100° C. one volume of sawdust to two volumes of water. The filtrate therefrom was added to flats of soil at the rate of one litre per square foot of soil. This concentration markedly suppressed root development and stem growth of garden peas and caused a marked twisting of the stems as shown in Figure 1. No positive evidence was obtained on the nature of the phytotoxic effect exerted by cedar sawdust. Cedar sawdust is quite acid in reaction, but its toxicity was not

significantly reduced by the neutralization of the sawdust or sawdust-soil mixtures with excess quantities of calcium carbonate. The acidity of equal volumes of sawdust and water was as follows: Cedar pH 3.0; Fir pH 4.2; Hemlock pH 4.2; Balsam pH 5.2.

Daffodils (variety King Edward), and tulips (variety Triton) were potted in the four sawdusts moistened with Hoagland's solution. Others were potted in soil and all were forced in the usual manner. Tabular data are not presented, for these reflected little information beyond evidence that cedar sawdust is markedly toxic towards both species of bulbs, and that none of the sawdusts is as favourable as soil as a forcing medium.

DISCUSSION

It would appear from these studies that useful information may be easily obtained upon the relative toxicities of different sawdusts to specific crops by planting the seed directly into pure sawdust moistened with water or Hoagland's solution. The value of such information is particularly important to British Columbia horticulturists, for in most of the agricultural areas they can secure sawdust in quantity at relatively low cost. These studies confirm the suspicions of horticulturists that cedar sawdust is highly toxic to a variety of crops. These investigations also support their conclusion that hemlock sawdust is less toxic than fir. The evidence of the non-toxicity of balsam sawdust to garden peas, beans, radish, and sweet peas is particularly interesting and suggests that this sawdust may be used for a variety of horticultural purposes. For example, in the production of seedling plants for transplant purposes, the seedlings may be grown in pure balsam sawdust with the following apparent advantages over soil. Flats filled with sawdust are lighter and therefore easier to handle and weeds are not a problem (Figure 2). The seedlings can be removed from sawdust flats more easily than from soil flats without damage to the roots.

These studies suggest also that information upon the ease with which a particular sawdust is attacked by soil organisms may be reflected by the inverse relationship of radish seed germination and subsequent seedling growth in a soil to which 20 per cent and 30 per cent sawdust has been incorporated, with the probable exception of sawdusts like cedar that exert a strong phytotoxic effect upon both germination and subsequent seedling growth. The small depression of radish seed germination and the large depression of subsequent seedling growth by incorporating balsam sawdust with soil compared with fir and the intermediate position of hemlock cannot readily be explained except by assuming that the large inverse relationship is a measure of the rate in which the soil organisms have attacked each sawdust. If this assumption is correct, then it may follow that the crude sugars in water extracts of balsam and hemlock sawdusts may be fermented with greater ease than corresponding extracts from fir in the production of industrial alcohol, or other fermentation products. Investigations of this nature covering all the principal sawdusts available in British Columbia and elsewhere should be carried out, owing to the importance of raw materials for industrial fermentation purposes and the importance of organic supplements in the management of soils.

BUNT SITUATION IN WINTER WHEAT IN ONTARIO[1]

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ABSTRACT

With the discovery of dwarf bunt (*Tilletia brevifaciens* G. W. Fischer) in winter wheat in one district in Ontario in 1952, samples of commercial winter wheat from this crop were collected for examination. Of the 93 samples examined, 20 were free of bunt spores, one bore spores of *T. brevifaciens* as well as spores of *T. caries* (DC.) Tul. and *T. foetida* (Wallr.)Liro, the common bunt fungi, and the remaining 72 were lightly to heavily contaminated with spores of *T. foetida*. Many samples also contained bunt balls.

The prevalence of bunt in winter wheat in Ontario was confirmed from the Grain Inspection records for Eastern Canada. The records show that bunt has been heavy in recent years. The practice of sowing late to escape Hessian fly damage favours the development of wheat bunt and may have been a factor in increasing the amount of bunt in Ontario.

INTRODUCTION

The recent discovery of dwarf bunt (*Tilletia brevifaciens*) in winter wheat in Ontario has led to a careful review of the bunt situation in the province at the present time.

Dwarf bunt was found in August, 1952, in a field of the variety Cornell 595 in York County. It is also known to occur on one other farm in the same district. The lateness of the season when the discovery was made prevented an intensive field survey for the smut. Instead, about 100 samples of winter wheat of both commercial and seed grade were assembled. Microscopic examination of preparations made from individual bunt balls or washings from the seed revealed the presence of dwarf bunt spores in one sample from Simcoe County. The spores were present in trace amounts along with a few spores of the two common bunt species. However, until a search is made in fields of the ripening crop in 1953, the distribution of the new bunt in Ontario must remain uncertain. On the other hand, the examination of these wheat samples disclosed an unexpected amount of the ordinary bunt on wheat in Ontario. The results will be discussed later in this paper.

HISTORY OF DWARF BUNT

Dwarf bunt appears to be a relatively new disease of wheat. It was first reported in 1935 (31) from Montana where it was first observed in 1931. However, also in 1931, the disease was observed in devastating proportions in Idaho and Utah and was noted also in Washington and Montana (25). By 1943 (16), it was known from at least "13 areas of infestation in the western wheat region" of the United States. Dwarf bunt was reported in New York State in 1945 (27) and in British Columbia in 1949 (10). Here again, it was known subsequently from herbarium specimens to have been present in both of these areas as early as 1931 (5, 8).

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[2] Mycologist and Senior Plant Pathologist, respectively.

It is now known to be distributed throughout the principal wheat-growing areas of New York (Tyler, *in litt.*), but the loss of crop has as yet been small. In British Columbia, the disease is virtually confined to the North Okanagan Valley (10). Its occurrence in Germany was reported in 1948 (28, 7) and in Austria in 1951 (24). The widespread occurrence of dwarf bunt by 1931, the year it was recognized in North America, suggests that the disease had already been present undetected for some time (8).

Plants affected by dwarf bunt are characterized by a greatly reduced stature (Plate I, Figure 7), being a third to a half the average height of the normal plants (18). Affected plants also tend to tiller excessively. However, the degree of dwarfing may differ, depending on variety and according to whether the plants are partially or completely smutted (18). Since the ordinary rough-spored bunt (*Tilletia caries*) also reduces the height of the plant, the only safe way of ascertaining which fungus is present is by a microscopic examination of the spores.

The dwarf bunt organism has been identified both as a variety (31) or race (15) of *Tilletia caries* (DC.) Tul. and as a distinct species, *Tilletia brevifaciens* G. W. Fischer (7). The spores of the organism are so strikingly distinct from either those of *T. caries* or the smooth spores of *Tilletia foetida* (Wallr.) Liro that there appears no valid reason for retaining the species in *T. caries* (Plate I, Figures 1-6). It is true that when monosporidial cultures of *T. brevifaciens* are appropriately paired with those of the other two species, there are formed hybrids, intermediate between the parents in their morphology and effect on the host (15). Some of the same phenomena were reported earlier in hybrids between *T. caries* and *T. foetida* (9). Resistance to dwarf bunt is apparently controlled by the same genetic factors that control resistance to the common bunts (18, 22). The phenomenon is not limited to the bunts, but embraces also *Urocystis tritici*, the cause of flag smut of wheat. Rex, a variety resistant to dwarf bunt, has proved resistant to flag smut (20). Incidentally, wheat plants may be simultaneously affected by both *Tilletia brevifaciens* and *Urocystis tritici*.

Plate I

FIGURE 1. Photomicrograph of spores of *Tilletia foetida* (Wallr.) Liro on *Triticum aestivum* var. Cornell 595, from a collection by J. D. MacLachlan, Paincourt, Ont., July, 1949, DAOM 23816. Note smooth spore wall. (×400).

FIGURE 2. Photomicrograph of spores of *Tilltia caries* (DC.) Tul. on *Triticum aestivum* var. Dawson's Golden Chaff from a collection by S. A. Bowman, Perth, Ont., 1945, DAOM 15446. Reticulation of the spores appears as low projections in median section. (×400).

FIGURE 3. Photomicrograph of spores of *Tilletia brevifaciens* G. W. Fischer on *Triticum aestivum* var. Cornell 595, from a collection by John S. Niederhauser, Churchville, N.Y., July 5, 1946, DAOM 19328. Note prominent reticulation of spores and evidence of gelatinous sheath. (×400).

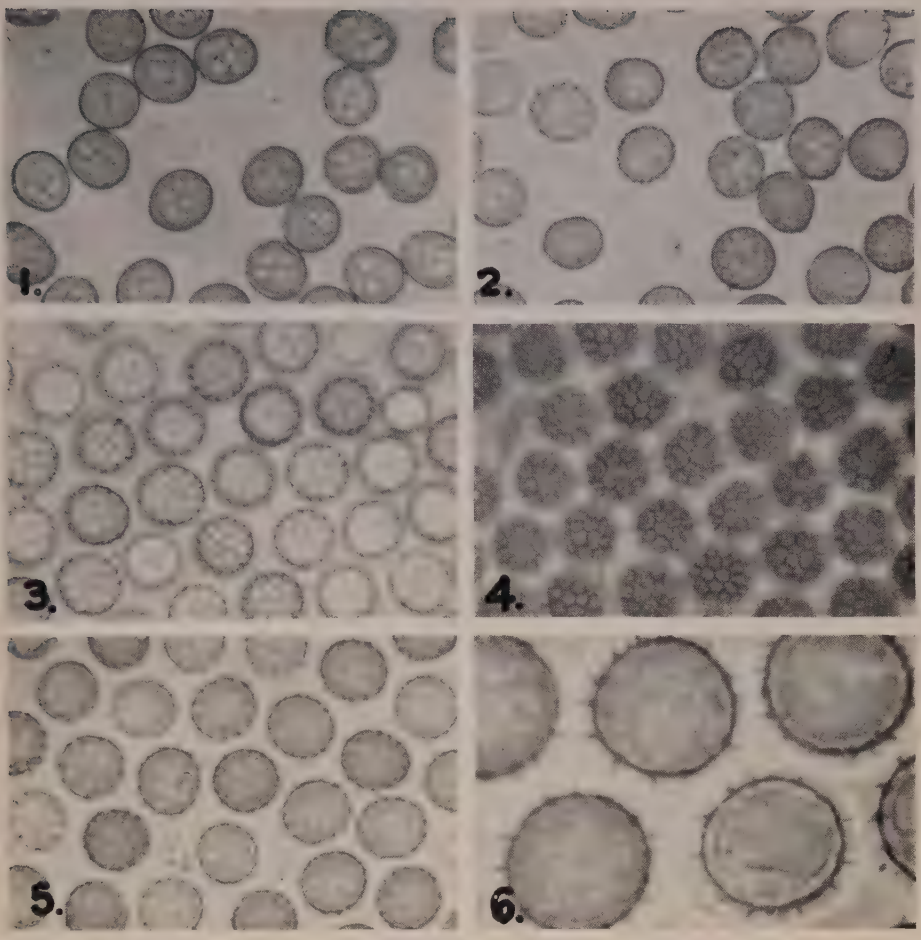
FIGURE 4. Same as Figure 3 to show surface reticulation of spores.

FIGURE 5. Photomicrograph of spores from type of *Tilletia brevifaciens* G. W. Fischer on *Agropyron intermedium*, Orofino, Idaho, Earl Horning, Aug. 1950, DAOM 34821. (×400).

FIGURE 6. Same as Figure 5 under oil immersion magnification. Note prominent spine-like projections and gelatinous sheath. (×950).

FIGURE 7. Portion of a field of Utah Kanred wheat showing heavy infection by dwarf bunt. Compare height of diseased plant and healthy culms. (Photograph by courtesy of D. C. Tingey, Utah State Agricultural College, Logan, Utah).

PLATE I



The spores of *T. brevifaciens* are formed in firm spore balls, which are not easily crushed but which, on weathering, permit the spores to escape and become smeared on other plant parts. The spores are almost uniformly globose, 17-22μ in diameter, with large polygonal reticulations, mostly 3-5μ wide and 1.5-2.5μ deep (Plate I, Figures 3-6). The segments of the reticulum appear as peg-like projections from the spore wall proper. Each spore is usually surrounded by a hyaline gelatinous sheath, 1.5-4μ thick. The sheath is most readily observed when the spores are mounted in Shear's medium (cf. Mycologia 32 :270. 1940), which permits them to swell to their normal size and shape. The sterile cells are few, sometimes encased in a hyaline gelatinous sheath.

The type of *T. brevifaciens* (7) is a collection on *Agropyron intermedium* from Idaho (Plate I, Figures 5-6) and the paratype a collection on wheat (*Triticum aestivum*) from Washington State. This species is also known to occur on rye (30) and tall oat grass (13).

Study of different collections of the dwarf bunt organism revealed that there is specialization within the species on the basis of spore germination, spore size, the prominence of the spore reticulation, etc. (18), and recently field evidence has been obtained of pathogenic specialization (22).

Dwarf bunt rarely develops in the resulting crop when seed contaminated with spores is sown in clean soil (18). When the spores, either free or in bunt balls, are once introduced into the soil, they may persist, however, for several years to infect a subsequent crop. Unlike the spores of *T. caries* or *T. foetida*, those of *T. brevifaciens* do not germinate promptly when they are placed under favourable conditions. Instead, the spores require a period of several weeks around 5° C. before they can be induced to germinate (23) and even then considerable time usually elapses before a large percentage of the spores has germinated. Field experiments indicate that wheat sown any time in the fall (29), many weeks after the soil was contaminated with spores, may become infected. Packing the soil (18) is known to increase infection. This fact may explain the greater incidence of dwarf bunt in the border sections of the field than elsewhere.

Since the dwarf bunt spores tend to persist in soil for several years, the most effective method of control is the growing of resistant varieties. Varieties carrying the Martin or Hussar gene complex have proved highly resistant to dwarf bunt (18) as well as many of the races of the common bunts. In fact, race T-16 (25) of *T. caries* and a special hybrid race, Hybrid 119, produced by crossing race T-8 of *T. caries* and a strain of *T. brevifaciens* (15), have proved sufficiently like the dwarf bunt organism in their pathogenicity (19) to permit their use as testers in breeding for dwarf bunt resistance. The breeding of varieties resistant to an increasing number of races has prevented losses from bunt from becoming widespread in the western wheat growing regions of the United States. It is believed that some progress has already been made in transferring the genes for resistance into a winter wheat suitable for growing in New York State and Ontario.

Only limited trials have so far been conducted to control dwarf bunt resulting from soil infection by the application of fungicides to the soil at the time of sowing of the winter wheat. Brassicol (pentachloronitrobenzene) at

40 gm. per sq. metre applied immediately after sowing appeared to give control in Germany (29). Recently, preliminary trials in the western United States (21) indicate that, of the four fungicides tested, Anticarie (hexachlorobenzene) gave significant control of dwarf bunt. The fungicides were first mixed with an equal quantity of pumicite or talc and 200 pounds of the diluted dusts per acre were blown into the drill row at the time of seeding. "Further tests with Anticarie and other chlorobenzene compounds are in progress at rates of application that are more practical economically" (21).

As mentioned earlier, dwarf bunt must have been present on wheat for a considerable period before it was detected. Some factors that may have operated are here enumerated. Infection by dwarf bunt (1) is depressed by the common bunts. Only rarely do dwarf bunt and common bunt occur in the same plant, whereas the two common bunt species occur quite commonly in the same plant or the same head or even occasionally in the same, but usually imperfectly formed, bunt ball. Just as the growing of highly resistant varieties has led to the establishment of physiologic races capable of attacking such varieties (17), so suppression of common bunt by means of resistant varieties may have permitted dwarf bunt to increase to destructive proportions leading to the recognition of its presence. Such factors may also account for its recognition in Germany and Austria.

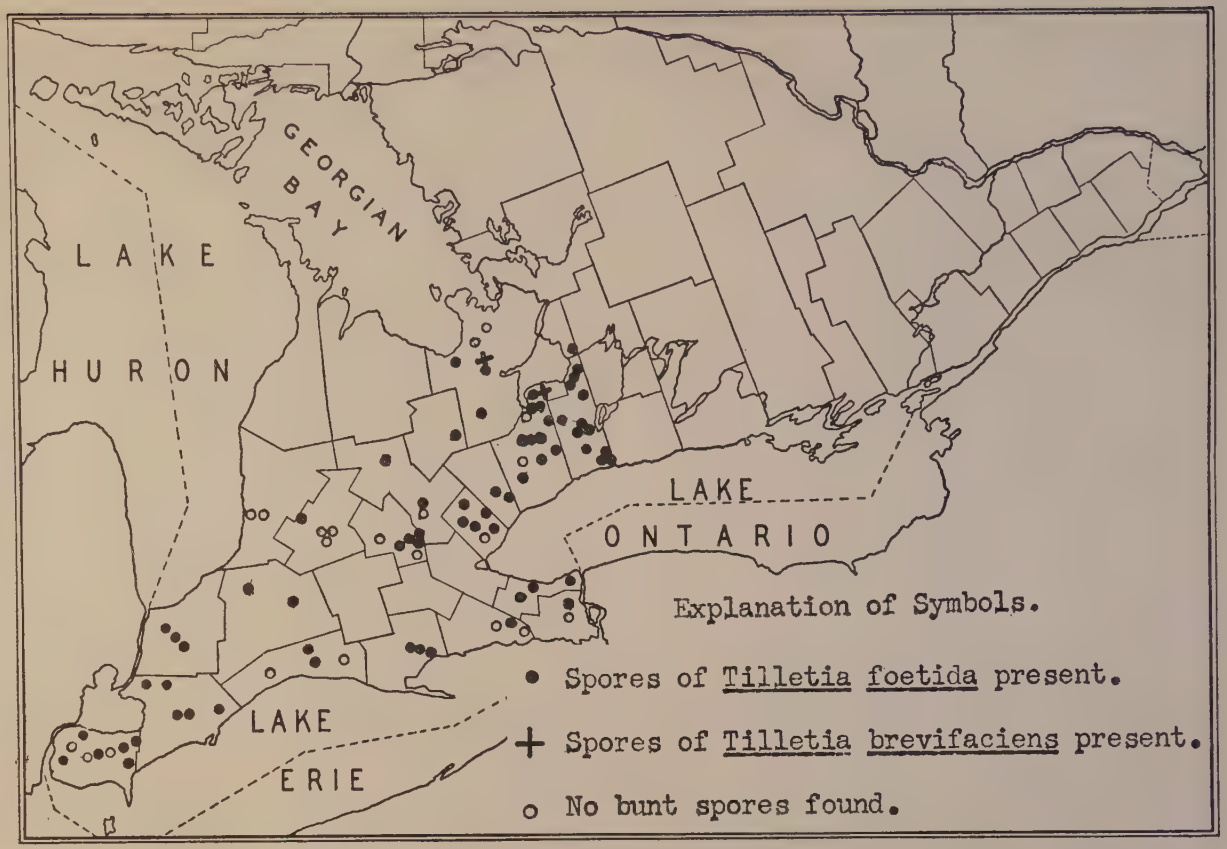
SURVEY FOR BUNT IN ONTARIO

The samples of winter wheat examined in the fall of 1952 were assembled in two ways. Several cleaning plants were visited by V. R. Wallen of this Division and 45 samples collected. An additional 48 samples were received from Agricultural Representatives through the courtesy of their Director, J. A. Garner, Ontario Department of Agriculture, Toronto.

When the samples were examined for bunt, a large proportion were found to be visibly smutty and many contained bunt balls or fragments of balls. The bunt organism present in the sample was determined by microscopic examination of a spore mount from a bunt ball. Where no bunt balls were present a small sample of the seed was shaken in water containing a detergent. The washings were centrifuged and a slide was made from the deposit. Of the 93 samples examined, one sample of Cornell 595 from Minesing, Simcoe Co., was found to be contaminated with spores of *T. brevifaciens* as well as those of *T. caries* and *T. foetida*, all in trace amounts.* Another 72 samples, or 77 per cent, were contaminated with spores of *T. foetida*. The distribution of the samples is shown in Map I. In collecting the samples, an effort was made to secure ones that were contaminated, but this selection can hardly be the explanation for the high percentage of samples carrying a heavy spore load.

Field observations on the occurrence of bunt in Ontario as recorded in the Annual Reports of the Canadian Plant Disease Survey show that bunt may be quite severe (up to 30 per cent of the heads destroyed) in

* Since this study was completed, Jean E. Newman, Plant Products Division, Production Service, continued, at our suggestion, the search for dwarf bunt. Examination of 38 samples of winter wheat, mostly intended for seed, revealed the presence of *T. brevifaciens* in two samples from Omemee, Victoria Co., and one sample from Belleville, Hastings Co. Her identifications were confirmed by us. Only 4 of the 38 samples were entirely free of bunt spores; the others were carrying low spore loads of *T. foetida* and occasionally *T. caries*.



MAP I. Distribution of bunt in winter wheat in Ontario as determined by an examination of grain samples from the 1952 crop. Each dot represents a single sample examined.

individual fields. These observations are too limited, however, to estimate the general level of infection from year to year. *T. foetida* has been the dominant species present.

A rough guide to the amount of visibly smutty grain being produced annually is provided by the Grain Inspection records for the Eastern

TABLE 1.—WINTER WHEAT PRODUCTION IN ONTARIO AND THE PERCENTAGE OF THE CROP IN EASTERN CANADA GRADING SMUTTY

Crop year	Class	Estimated production[1] (000,000)	Inspected[2] (000)	Graded smutty[2] (000)	Percentage smutty
		bu.	bu.	bu.	
1952	White Winter		1,442	121	8.7
Aug.-Oct.	Total	20.8	2,869	172	6.0
1951–52	White Winter		4,644	396	8.5
	Total	19.7	9,000	559	6.2
1950–51	White Winter		3,258	165	5.0
	Total	30.0	10,714	238	2.2
1949–50	White Winter		1,029	62	6.1
	Total	24.7	6,323	215	3.4
1948–49	White Winter		1,504	108	7.2
	Total	26.0	12,745	328	2.6
1947–48	White Winter		23	—	0.0
	Total	17.7	2,122	163	7.7
1946–47	White Winter		146	26	17.5
	Total	16.2	977	159	16.2
1945–46	White Winter		262	15	5.6
	Total	20.1	2,912	123	4.2
1944–45	White Winter		57	1	2.1
	Total	20.9	1,627	62	3.8
1943–44	White Winter		14	—	0.0
	Total	13.2	498	7	1.5
1942–43	White Winter		75	—	0.0
	Total	23.4	1,336	14	1.0
1941–42	White Winter		95	1	1.1
	Total	15.1	752	16	2.1
1940–41	White Winter		153	1	0.8
	Total	22.0	2,082	19	0.9
1939–40	White Winter		267	2	0.7
	Total	22.2	3,253	46	1.4
1938–39	White Winter		162	—	0.0
	Total	19.8	1,695	16	0.9

[1] From Quarterly Bull. Agr. Statistics, Canada: Yield of winter wheat in Ontario.

[2] From the Grain Statistics Weekly or the Reports on the Grain Trade of Canada issued jointly by the Bureau of Statistics and the Board of Grain Commissioners for Canada.

Division since the bulk of the winter wheat produced in Eastern Canada is grown in Ontario. In Table 1 is shown the estimated annual production of winter wheat in Ontario, the amount of winter wheat inspected each year, and the amount and percentage of the inspected crop that graded smutty. On account of the importance of the White Winter class in the milling of pastry flour, the Inspection data on this class are shown separately. Data were collected as far back as 1922-23, but as no grain was recorded as smutty earlier than 1938-39, the figures for these early years are omitted. It will be seen that in the first quarter of the crop year 1952-53, 8.7 per cent (121,000 bu.) of the White Winter wheat and 6.0 per cent (172,000 bu.) of all the winter wheat inspected was graded smutty. Indeed, the losses, with considerable fluctuation, have been high since 1945-46. If the part of the crop inspected was at all representative, over one million bushels produced in Ontario in 1952 would grade smutty upon inspection. Because there is no precise point at which the amount of bunt in the standing crop will cause the grain from that crop to be graded smutty it is impossible to estimate the loss caused, but the high percentage of crop graded smutty in recent years suggests that this loss is considerable.

DISCUSSION

The marked prevalence of bunt in winter wheat in Ontario is suggested by the heavy spore load carried by many samples examined. Bunt is, of course, much less prevalent in spring wheat than in winter wheat. In 1946-47 (4) the percentage of cars that graded smutty in Western Canada was 0.45, a high figure. An examination of 8,267 wheat samples from the same crop by the Line Elevators Service at Winnipeg disclosed 28.6 per cent of the samples free of bunt spores, 45.5 per cent with a trace or light spore load, 23.9 per cent with a heavy spore load and 1.9 per cent with a heavy spore load and bunt balls or fragments of balls. When the 93 samples of winter wheat from Ontario were similarly classified, it was found that 21 per cent of the samples were clean, 9 per cent with a trace or light spore load, 12 per cent with a heavy spore load, and 58 per cent with a heavy spore load and bunt balls.

The predominance of the smooth-spored *Tilletia foetida* over the rough-spored *T. caries* in Ontario agrees with previous observations on the relative prevalence of the two species in North America. It is evident that even 50 years ago (2), *T. foetida* was the more abundant species. In 1918 (14) *T. caries* was the dominant or only species in Oregon, Washington and in northern Idaho, but since then (25) *T. foetida* has become more prevalent in these states. *T. caries* is also the dominant species in the northern part of the three Prairie Provinces (3, 12). Moreover, in the durum wheat area in the Upper Mississippi Valley (26) and in southern Manitoba and Saskatchewan (12) bunt in this crop is caused almost exclusively by *T. caries*, although *T. foetida* is the dominant species in common wheat. In the Mycological Herbarium of the Division, there are 5 collections of *T. foetida* and only one of *T. caries* from Ontario. The cause of the greater prevalence of *T. foetida* over *T. caries* is unknown, as soil temperatures of 5°-15° C. are necessary for heavy infection to occur with either species (6).

The present high infection in Ontario may be due to more farmers sowing their crop late to escape Hessian fly damage, one of the recommendations for the control of this insect (11). Because soil temperatures are more favourable for infection later in the season, such a practice will tend to increase the amount of bunt developing in the crop. It then becomes all the more imperative that the seed before sowing be carefully treated with a fungicide to destroy any spores that may be present on the seed.

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STUDIES ON THE EGYPTIAN BUFFALOES

I. SELECTION FOR MILK YIELD

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ABSTRACT

The effect of culling in a dairy herd of buffalo is explained. The annual genetic gain due to selection of dams of buffalo cows and dams of buffalo bulls was 1.56 lb. milk yield.

Progress in dairy buffalo improvement through selection is limited, because only part of the variation in their milk production is caused by genetical differences. Moreover, milk yield is sex-limited in its expression. Therefore, the accuracy with which the breeding animals are selected determines the amount of improvement achieved.

When progeny testing is not used in the dairy herds, the method of Rendel and Robertson (7) may be used to calculate the amount of genetic gain due to the selection practised. This method has been used by several workers who have estimated the genetic gain in milk yield (6, 8) and butterfat test (1) in dairy cattle. The results of selection for milk yield in a buffalo herd are reported in the present paper.

SOURCE OF DATA

The number of recorded herds in Egypt is limited. The herd used in this study is an open herd maintained commercially and was founded in 1928 near Alexandria. In this herd, the system of feeding and management is above the average of the country. The buffalo cows calving suckled their young for about 30 days, after which they were milked twice daily over an average period of 300 days.

RESULTS AND DISCUSSION

Selection and Variability

The variation of the population is not known, although an estimate can be made from the standard deviations of the sample, i.e., the herd. The average yields for successive lactations by all the animals recorded, the standard deviations of the yields falling in a given lactation and the corresponding coefficients of variation (9) are presented in Table 1, together with the corresponding data for the dams only.

The standard deviation, and the coefficient of variation for all recorded members were highest at the first lactation, after which they did not show any regular trend. Similar estimates obtained for the dams alone were rather variable. The variations among the dams were slightly less than those for the whole population.

TABLE 1.—MEAN YIELDS OF ALL RECORDED MEMBERS OF THE HERD BY LACTATION AND OF THE DAMS CONSIDERED SEPARATELY

Lactations	All the herd				The dams			
	Number	Yield	σ Gallons	C/V	Number	Yield	σ Gallons	C/V
1	198	378	129.7	34.31	121	381	122.5	32.15
2	190	398	123.9	31.13	112	410	121.6	29.65
3	167	400	124.5	31.12	96	399	131.3	32.90
4	145	378	115.0	30.42	73	379	107.8	28.44
5	108	384	127.6	33.22	48	375	118.1	31.49
6	71	371	122.3	32.96,	34	359	120.1	33.45
7	46	374	105.7	28.26	20	373	97.8	26.21
8	28	404	92.2	22.82	8	399	103.9	26.04
9	19	359	107.0	29.80	6	345	111.9	32.43
10 and over	20	335	130.2	38.86	—	—	—	—
Average or total	992	385	122.2	31.74	518	388	119.9	30.90

The Result of Culling

The process of selection for milk yield in the present study is divided into two parts: (*a*) the selection of dams of future buffalo heifers, and (*b*) the selection of dams of future buffalo bulls (7).

The selection of dams may not reflect the length of their productive herd-life. However, some buffalo cows are culled at a later age and their progeny are not used for breeding. The effect of culling is expected to increase the average milk yield of the remainder over the average milk yield of the population from which they were drawn. Consequently, the average difference between the milk yield of the non-culls in each lactation and all the animals in the same lactation was calculated from data from animals which had completed their herd-life records. This difference is called the culling differential. The results obtained are shown in Table 2.

The table below gives the number of animals in each lactation, the per cent culled and the culling differential. For example, 198 animals gave a first lactation, 6.06 per cent of these animals were culled after their

TABLE 2.—CULLING DIFFERENTIAL FOR MILK YIELD IN THE HERD

Lactations	Number of cows	Number culled	Culling differential
		%	lb.
1	198	6.06	+ 20.29
2	190	12.63	+ 35.74
3	167	13.77	+ 2.61
4	145	25.51	− 6.52
5	108	35.18	− 50.16
6	71	36.62	− 10.60
7	46	39.13	− 17.65
8	28	60.71	− 4.36
9	19	57.89	− 12.80

first lactation, and the average yield of the remainder was + 20.29 lb. milk yield superior over the average yield of all first lactations.

The culling differential increased from first to second lactation, and then declined. However, selection for yield appears to have been ineffective after the third lactation. The rate of culling rose from early to later lactations, probably because of old age and disease.

In the study of the variability, and the culling differential, the calculations for later lactations were based on small numbers to which very little weight can be attached.

The average genetic superiority due to selection of dams of buffalo heifers was obtained by use of the following expression (>):—

$$\frac{\Sigma n h^2_l (Y_l - \overline{Y})}{\Sigma n}$$

where n is the number of daughters which come into the herd for each dam

h^2_l is the heritability based on l lactation yields

$\overline{\gamma}$ is the mean of the first lactation yields of the whole herd

Y is the mean of the lactation yields on which the dam was judged.

The rate of genetic improvement due to selection of dams of buffalo bulls was calculated in the same way, but, in this case, n refers to the number of daughters the son of each dam had.

The heritabilities used are given in Table 3.

TABLE 3.—HERITABILITY OF MILK YIELD

Records averaged	Heritability
1	0.31
2	0.40
3	0.44
4	0.46
5	0.48

The heritability of single records was based on the first lactation yields and was obtained by the intra-sire regression method (5). The number of daughter-dam pairs and sires used was 94 and 9, respectively. The estimates for the average records were calculated from the heritability and repeatability (4) of single records (3). The repeatability obtained was 0.55.

No correction for age was introduced when averaging the records, because age did not have any statistically significant effect on production. The rate of genetic improvement in the herd is set out in Table 4.

TABLE 4.—GENETIC GAIN FOR MILK YIELD OF DAMS OF BUFFALO COWS AND DAMS OF BUFFALO BULLS

Genetic gain based on 1–5 lactations (lb.)		Number of daughters	Number of bulls
Dams of B. cows	12.5	188	—
Dams of B. bulls	29.6	30	9
Total	42.1	—	—

The results showed that the number of bulls bred in the herd was small. However, the intensity of selection between the males was higher than between the females. As Rendel and Robertson (7) have pointed out, a more rapid advance could thus be achieved on the male side, but nevertheless it is not good reason for relaxing culling, because by the latter method it is possible to maintain the average yield of the herd under optimum conditions of selection at a level of about 2 per cent higher than with no culling.

Accordingly, the total generation lengths were obtained in order to estimate the annual genetic gain (2). Rendel and Robertson (7) have shown that the total generation lengths in dairy cattle represents four times the average intervals between generations. Therefore, 100 male and 100 female offspring were taken and the average ages of their parents when they were born were obtained with the following results:

$$L_{CC} = 7.5 \text{ years}$$

$$L_{CB} = 7.4 \text{ years}$$

$$L_{BC} = 5.8 \text{ years}$$

$$L_{BB} = 6.3 \text{ years}$$

$$\Sigma L = 27.0 \text{ years}$$

where, L_{CC} is the average age of the buffalo cows when the buffalo heifer calves are born; L_{CB} is the average age of the buffalo cows when the buffalo bull calves are born; L_{BC} is the average age of the buffalo bulls when the buffalo heifer calves are born, and L_{BB} is the average age of the buffalo bulls when the buffalo bull calves are born.

This high value of the total generation lengths was anticipated because the herd was increasing in number. Moreover, the average age of the animals at first calving and their calving intervals were 39.4 and 21.6 months, respectively. The annual genetic gain was $(12.5 + 29.6)/27 = 1.56$ lb. milk yield which is to be regarded as rather small.

SUMMARY

The study reported here showed the rate of culling for milk yield in a herd of buffalo. The annual genetic gain due to selection of dams of buffalo cows and dams of buffalo bulls was 0.04 per cent of the herd average.

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ADDENDUM

The effect of age at first calving on length of productive life, yield and reproduction in the buffalo herd previously studied was observed.

In 284 cows, covering a wide range of ages at first calving, it was noted that age at first calving had no significant effect on the yield in the first lactation or on the length of life of the cow in the herd.

In a study of 140 cows with four complete lactations, age at first calving had no significant effect on length of calving intervals or on production in the first four lactations. Repeatability of the calving interval was calculated to be 0.12.

This study suggests that there was no disadvantage in breeding buffalo cows to calve at an early age. Judging by the repeatability of the calving interval, heredity was of minor importance in determining the calving intervals.

September 22, 1953. —K. A. ALIM

DIGESTIBILITY STUDIES WITH SWINE

VII. GROSS ENERGY VALUES AND ETHER EXTRACT DETERMINATIONS

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ABSTRACT

The digestibility of two vegetable protein supplements and of three animal protein supplements in a barley ration was determined with six Yorkshire barrows. The Goldfisch extraction method and Wood and Simpson's acid hydrolysis procedure were compared in the determination of the ether extract component of faeces. Digestible gross energy values, particularly of tankage and meat meal, calculated from the chemical composition obtained by the acid hydrolysis method for ether extract, agreed more nearly with those obtained with the bomb calorimeter than did the values obtained by the Goldfisch extraction method. Significant differences were found between the two extraction procedures in calculating the total digestible nutrients of tankage and meat meal. It was concluded that in digestibility trials with pigs erroneous results may be obtained if adequate precautions are not taken in the determination of faecal ether extract.

INTRODUCTION

The associative digestibility between barley and tankage was studied by Watson *et al.* (2) in a previous paper in this series. It was concluded that, as a general rule, there were no associative digestibility effects. The six rations comprised barley alone and barley with tankage at 20 to 90 per cent. The coefficient of digestibility of ether extract of the barley ration was 58 per cent, while that of the ration containing 20 per cent tankage was 92 per cent. The mean coefficient ascribed to the ether extract of tankage was 97 per cent. It was startling to find that the inclusion of 20 per cent of tankage in the barley ration had raised the apparent digestibility of the ether extract contributed by barley from 58 to 90 per cent.

The observed energy value (Parr bomb calorimeter) of the faeces from barley-fed pigs was 10 per cent higher than that calculated from the chemical composition. The addition of tankage to the ration increased the discrepancy between the observed and calculated values to about 20 per cent. It was thought probable that the high faecal ash, 10 per cent with the barley ration and from 30 to 60 per cent when tankage was added, resulted in the formation of ether insoluble soaps. Wood and Simpson's acid hydrolysis extraction method (3) was employed and found to give significantly greater values for ether extract. Recalculation of the energy value of faeces, using these higher values for ether extract, reduced the discrepancy between observed and calculated energy values to a minimum.

The experiment reported here was undertaken to determine the extent to which calculated gross energy coefficients and total digestible nutrients of other protein supplements were affected by the method of determining ether extract. Two vegetable protein supplements were used along with three animal protein supplements. At similar levels of feeding the former do not result in as high faecal ash as the latter. Calcium determinations

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were undertaken, although it was realized other minerals might result in bound fat not extracted by the Goldfisch extraction method.*

EXPERIMENTAL

Digestibility trials were carried out on rations containing equal parts by weight of barley and one of five protein supplements as follows:

Linseed oil meal (LOM) Sherwin-Williams screwpress
Soybean oil meal (SBOM) Canadian Vegetable Oils, Ltd.
Tankage — Canada Packers 50 per cent Feeding
Meat meal — Canada Packers 50 per cent Feeding
Fish meal — National Sea Foods Whitefish Meal

The experiment was in the form of a 6 × 6 randomized latin square. Six barrows were employed. They weighed 60-75 lb. at the beginning of the first period and 147-182 lb. at the end of the sixth period. Feeding practice, sampling of feeds and collection schedules were in accordance with procedures currently used in this laboratory and previously described for experiments of this design. In addition to the regular chemical analyses, ether extract was also determined by the acid hydrolysis method of Wood and Simpson (3) modified by weighing the final extract instead of titrating with standard sodium hydroxide. Caloric values were determined in the Parr bomb calorimeter.

Gross energy coefficients were calculated from the chemical analyses, using ether extract of faeces analysed by both the Goldfisch extraction and the acid hydrolysis methods. Wood and Simpson's (3) method for ether extract was developed primarily for faeces; when used on feeds the values were some 10 per cent lower than those obtained by the Goldfisch extraction method. The calculated energy coefficients were compared with the gross energy coefficients determined with the calorimeter. Mean energy values [Atwater (1)] for carbohydrates, fats and proteins were used in calculating the energy coefficients. Calcium content of the faeces was determined to see if a relationship existed between the amount of calcium present and the amount of fat which was freed by acid hydrolysis.

RESULTS

The acid hydrolysis method for determining ether extract gave on the average a 10 per cent lower value with the feeds than was obtained by Goldfisch extraction. This was not so with faeces, where the type of protein supplement fed had a marked effect on the results. This is evident in Table 1, where mean values for the six animals on each ration are given.

When barley was supplemented with vegetable protein supplements the difference between the two extraction methods was less pronounced than it was with the animal protein supplements. There was no close correlation between faecal calcium and "bound fat" but the difference between the two extraction procedures was greater when the faecal calcium exceeded 3 per cent.

* Goldfisch Extraction apparatus is manufactured by the Laboratory Construction Co., Kansas City, Mo., and is currently in use in a large number of laboratories engaged in feeding stuff analyses. The apparatus has been described in numerous bulletins distributed by the makers. The principle is rapid distillation of a petroleum solvent, having a boiling range of 35° to 60° C. The condenser is highly efficient and the sample, 1 to 5 gm., is continuously covered with solvent. Extraction is complete in 4 hours.

TABLE 1.—ETHER EXTRACT OF FAECES*

Ration	Method of extraction		Difference as per cent of acid hydrolysis	Calcium content of faeces
	Goldfisch	Acid hydrolysis		
Barley	5.40	6.65	19	0.14
L.O.M.	5.25	6.38	18	0.30
S.B.O.M.	5.04	5.60	10	0.33
Tankage	1.48	8.82	83	3.66
Meat meal	1.89	10.70	82	4.09
Fish meal	1.78	5.25	66	4.72

Values given as per cent of dry matter.

TABLE 2.—MEAN GROSS ENERGY COEFFICIENTS OF PROTEIN SUPPLEMENTS*

Supplement	Basis of calculation		
	Bomb calorimeter	Ether extract determination	
		Goldfisch	Acid hydrolysis
L.O.M.	69.3	72.5	72.0
S.B.O.M.	82.8	84.1	84.1
Tankage	62.3	70.1	64.6
Meat meal	69.1	78.4	72.3
Fish meal	88.0	90.7	88.6

* Necessary difference for significance at ($P = 0.01$) = 0.96.

Gross energy coefficients for the five protein supplements were calculated from the data for mixed rations with barley. Mean values for the six periods are shown in Table 2, together with values calculated from the chemical composition, employing both methods for determining ether extract in faeces. It is apparent that in the case of tankage and meat meal the discrepancy between calculated and observed values was significantly reduced when the acid hydrolysis method was employed.

Mean values for total digestible nutrients in the five protein supplements are given in Table 3. The differences between the two methods of extraction are significant in the case of tankage and meat meal.

DISCUSSION

It seems evident from the results of this experiment that standard feeding stuffs analysis commonly employed in digestibility trials with pigs may give erroneous results with animal protein supplements such as tankage and meat meal. The acid hydrolysis method of Wood and Simpson, when applied to faeces analysis, results in calculated digestible gross energy values which check more closely with those obtained with the bomb calorimeter. It is apparent from Table 1 that the Goldfisch extraction does not remove all the faecal "fat". This results in an appreciably higher apparent coefficient of digestibility of the fat and hence an exaggerated

TABLE 3.—MEAN TOTAL DIGESTIBLE NUTRIENTS OF PROTEIN SUPPLEMENTS*

Supplement	Ether extract determination	
	Goldfisch	Acid hydrolysis
L.O.M.	74.0	73.2
S.B.O.M.	82.7	82.5
Tankage	60.7	54.4
Meat meal	72.1	65.3
Fish meal	71.2	69.2

* Necessary difference for significance at (P = 0.01) = 1.6.

calculated gross energy coefficient. Similarly total digestible nutrients (T.D.N.) for tankage and meat meal which were calculated from coefficients based on the acid hydrolysis method for ether extract were undoubtedly better estimates of the true value. This difference of 10 per cent in the T.D.N. of tankage and meat meal based on the two extraction procedures is of practical significance.

Calcium appears to be partially correlated with the amount of bound fat, but is not the sole factor. The results with fish meal, which in common with tankage promotes a high faecal calcium, indicate that other factors are involved. Baking of faeces is unlikely to have been a factor in this experiment as the maximum temperature of the faeces during dehydration was 70° C. A more detailed study of extraction procedures seems necessary. Whether a similar discrepancy between observed and calculated gross energy values occurs in ruminants is not known, but is currently being studied.

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CROWN ROT OF FRUIT TREES IN BRITISH COLUMBIA

II. ROOTSTOCK AND SCION RESISTANCE TRIALS OF APPLE, PEAR, AND STONE FRUITS[1]

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ABSTRACT

Various apple, plum, apricot, peach, and cherry rootstocks, and pear rootstocks and scions were inoculated with a mixed culture of four isolates of *Phytophthora cactorum* obtained from apple. Disease ratings were calculated by a method which indicated maximum susceptibility by 100 and maximum resistance by a score of zero. The ratings obtained are as follows: apple, 0-40, pear, 1-85, plum, 3, apricot, 19, peach, 28-29, cherry, 3-62. When a fifth isolate obtained from sweet cherry was added to the inoculum, and Mazzard cherry F-12-1 clonal stocks and *Pyrus robusta* seedlings were reinoculated, their disease ratings rose from 27 to 53 and from 18 to 67, respectively.

INTRODUCTION

The crown rot caused by *Phytophthora cactorum* (L. & C.) Schroet. has been widespread in the Okanagan Valley of British Columbia for many years. The first paper of this series (2) reported the resistance of 40 different apple varieties and seedlings when artifically inoculated with this fungus. The present paper gives the results of further trials on apple rootstocks, and in addition, trials on stone fruit rootstocks and on pear rootstocks and scions.

MATERIALS AND METHODS

The trees were planted on a sandy loam under furrow irrigation, and were inoculated when two years old.

The inoculum used in all but the 1952 inoculations consisted of a mixture of the four isolates of *P. cactorum* from apple used previously (2). In 1952, a fifth isolate obtained from a diseased sweet cherry crown was added to the mixture, and such a marked difference in reaction was recorded that the 1952 results will be considered separately. The isolates were grown separately on a mixture of corn meal, pea extract, and vermiculite, and were mixed just before they were used.

All inoculations were made below ground level. A vertical strip of bark 3/16 inches wide was folded back, inoculum was smeared on the exposed cambium, and the strip was replaced. Scion inoculations were made across the root-scion union. Inoculations were made in mid-June and the amount of girdling in each tree was measured in mid-September. Trees that were living after the first inoculation received a second one on the opposite side of the trunk the following season. The larger of the two measurements thus obtained was used in deriving the disease ratings.

The disease ratings were calculated by the method previously described (2), in which the total amount of rot present in all trees of a particular variety was expressed as a percentage of the maximum amount of rot possible for that variety.

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RESULTS AND DISCUSSION

Disease ratings of the apple rootstocks are listed in Table 1. As in the earlier investigations (2), Antonovka and Columbia seedlings, Malling IX and *Pyrus robusta* clonal roots, and Delicious, Jubilee, Spartan, and Winesap on their own roots, showed considerable resistance. McIntosh

TABLE 1.—PATHOGENICITY OF *Phytophthora cactorum* ON VARIOUS APPLE ROOTS ARTIFICIALLY INOCULATED FOR TWO SUCCESSIVE YEARS WITH A MIXED CULTURE OF FOUR ISOLATES

Varietal composition of tree		Roots inoculated	Roots developing crown rot	Disease rating
Root	Scion			
				%
Seedling roots—				
Antonovka seedlings		41	21	8
Beautiful Arcade	McIntosh	54	41	17
Bedford seedlings		33	9	4
Columbia seedlings		56	25	8
McIntosh	Delicious	23	19	20
	Jubilee	25	19	10
	Spartan	24	14	7
	Winesap	24	22	17
Clonal roots—				
Malling II	Spartan	15	11	12
Malling VII		29	17	7
Malling IX		10	0	0
Malling XVI	S-5-4	18	17	40
Malling XVI		10	10	35
Pyrus robusta No. 5		91	46	9
Own roots—				
Delicious		10	6	8
Jubilee		31	24	8
Spartan		15	9	7
Winesap		15	12	11

TABLE 2.—PATHOGENICITY OF *Phytophthora cactorum* ON VARIOUS PEAR ROOTS ARTIFICIALLY INOCULATED FOR TWO SUCCESSIVE YEARS WITH A MIXED CULTURE OF FOUR ISOLATES

Varietal composition of tree		Roots inoculated	Roots developing crown rot	Disease rating
Root	Scion			
				%
Seedling roots—				
Bartlett seedlings		22	3	2
Bartlett	Anjou	22	3	2
	Bartlett	20	8	6
	Flemish Beauty	20	12	8
	Gorham	23	6	5
Old Home seedlings		25	4	2
Old Home	Anjou	28	6	6
	Bartlett	19	5	3
	Bosc	9	2	3
	Flemish Beauty	27	12	6
	Gorham	18	4	8
	Old Home	38	8	3
French pear seedlings		18	3	2

seedlings again varied in susceptibility. Malling II and Malling XVI clonal roots showed a slight increase in susceptibility over that previously observed. Malling VII clonal roots and Bedford seedlings were tested for the first time in these trials and proved to be resistant.

Disease ratings of pear rootstocks are given in Table 2, and of pear scions in Table 3. The data in Table 2 indicate that Bartlett, Old Home, and French pear seedlings, commonly used as rootstocks in the Okanagan Valley of British Columbia, are resistant. Table 3 illustrates the very low resistance of the Flemish Beauty and Gorham varieties. However, as shown in Table 2, the high susceptibility of these scions did not diminish the resistance of the rootstocks on which they were grown. The susceptible pear varieties displayed a reaction markedly different from that observed in apple, in that the above-ground portion of the scions was frequently girdled while only a small amount of rot developed around the point of inoculation below ground level. In the apple varieties, the spread of infection was usually confined to the tissue below ground level.

The relative susceptibility of several stone fruit rootstocks is illustrated in Table 4. The plum seedlings tested appeared to be resistant, but with the small number involved, a definite conclusion could not be reached. Both the Tilton apricot and peach seedlings were partially susceptible. The two cherry rootstocks, Gold and Mazzard, commonly used in British Columbia plantings, proved to be very susceptible. Mahaleb seedlings were quite resistant.

It was characteristic of cherry, and to a lesser extent of peach stocks, that lesions spread more rapidly upwards from the point of inoculation, than downwards or laterally. Trunk girdling was more frequent above than below ground level, even though inoculation was made in the root. Spread of infection in stone fruit varieties was accompanied by the exudation of large amounts of gum from the affected portion of the trunk.

TABLE 3.—PATHOGENICITY OF *Phytophthora cactorum* ON VARIOUS PEAR SCIONS ARTIFICIALLY INOCULATED FOR TWO SUCCESSIVE YEARS WITH A MIXED CULTURE OF FOUR ISOLATES

Varietal composition of tree		Scions inoculated	Scions developing crown rot	Disease rating
Seedling root	Scion			
				%
Bartlett	Anjou	22	7	4
Old Home	Anjou	19	4	8
Bartlett	Bartlett	20	5	11
Old Home	Bartlett	10	1	1
Bartlett	Flemish Beauty	20	20	64
Old Home	Flemish Beauty	14	14	78
Bartlett	Gorham	23	20	73
Old Home	Gorham	18	16	85

TABLE 4.—PATHOGENICITY OF *Phytophthora cactorum* ON VARIOUS STONE FRUIT ROOTS ARTIFICIALLY INOCULATED FOR TWO SUCCESSIVE YEARS WITH A MIXED CULTURE OF FOUR ISOLATES

Varietal composition of tree		Roots inoculated	Roots developing crown rot	Disease rating
Root	Scion			
				%
Seedling roots—				
Plum*	Italian prune	8	2	3
Tilton apricot seedlings		54	54	19
Peach**	Redhaven	4	4	19
	Valiant	7	7	27
	Vedette	9	9	32
Peach seedlings†		52	43	29
Gold cherry seedlings		40	37	62
Mahaleb cherry seedlings		43	4	3
Mazzard cherry seedlings		60	57	41

* Parentage of rootstock unknown.
** Roots of unknown parentage within Valiant-Vedette-Veteran group.
† Mixed seedlings of Muir and Elberta.

TABLE 5.—DIFFERENCE IN DISEASE RATINGS OBTAINED FROM ROOTS INOCULATED IN 1951 WITH A MIXED CULTURE OF FOUR ISOLATES, AND AGAIN IN 1952 WITH A MIXED CULTURE OF FIVE ISOLATES OF *Phytophthora cactorum*

Variety	Roots inoculated	Disease ratings	
		1951	1952
		%	%
Bartlett pear seedlings	13	0	3
Gold cherry seedlings	83	49	51
Mahaleb cherry seedlings	14	0	7
Mazzard cherry seedlings	14	26	44
Mazzard F-12-1 clonal stocks	49	27	53
Pyrus robusta seedlings	11	18	67

Table 5 shows the marked increases in susceptibility that were observed when rootstocks that had been inoculated in 1951 with the four isolates from apple used in all previous tests were reinoculated in 1952 with a fifth isolate, recovered from sweet cherry, added to the inoculum. There was no appreciable difference between the 1951 and 1952 disease ratings of the Bartlett pear, and of Gold and Mahaleb cherry seedlings. However, the 1952 ratings for Mazzard cherry seedlings, Mazzard F-12-1 clonal roots, and *P. robusta* seedlings were much higher than those obtained in 1951.

In all trials prior to 1952 in which *P. robusta* seedlings and clonal stocks were inoculated with the mixture of four isolates obtained from apple, these roots had been fairly resistant. However, with the addition of the new isolate to the inoculum in 1952, the disease rating of the *P. robusta* seedlings rose from 18 to 67. Whether or not the increased susceptibility displayed by these rootstocks in 1952 may be attributed to differential pathogenicity of the new isolate is not yet known. Baines (1) found evidence of host selectivity among his strains of *Phytophthora cactorum*. It is possible that the use of additional isolates in rootstock resistance trials will reveal the existence in British Columbia of strains readily pathogenic on other varieties hitherto considered resistant.

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NOTE ON EVALUATING POPULATIONS OF THE SHEEP KED, *MELOPHAGUS OVINUS* (L.) (DIPTERA: HIPPOBOSCIDAE), ON FEEDER LAMBS

Accurate estimates of numbers of the sheep ked, *Melophagus ovinus* (L.), are necessary rather than actual counts where populations are to be determined on a relatively large number of animals. Macleod (1) indicated that "total live counts" closely approximated the number of keds present. Muma *et al.* (2) stated that a count of the keds exposed in ten 12-inch wool partings on each side of a lamb was a valid sample ($r = + 0.888$) of the population.

At Lethbridge, the following four methods of estimating ked populations were tested on a group of infested feeder lambs: (*a*) A 5-minute count, counting all the keds observed by parting the fleece systematically from front to rear for 5 minutes, about 2.5 minutes being spent on each side of the animal; (*b*) The method described by Muma *et al.* (2); (*c*) A vertical-parting count, counting all the keds noted in fleece partings extending from the mid-back to the mid-belly. The partings were spaced at 4-inch intervals on both sides of the lamb, beginning at the anterior point of the shoulder; (*d*) The "total live count", counting all keds observed on parting the entire fleece.

The actual population, or "picked-off" count, was determined by picking off all the keds from each animal. The only equipment used was a grooming stand to restrain the animal on its feet, a hand tally, and an interval timer.

The efficiency of each method of estimation was determined by means of correlation and regression analyses (Table 1). The coefficients of correlation indicated a highly significant relationship between estimates for individual lambs and the "picked-off" count.

The "total live count", although preferable for some purposes, is time-consuming and impractical when large numbers of animals must be assessed. The 5-minute count, a rapid method, has two limiting factors:—

TABLE 1.—EFFICIENCIES OF FOUR METHODS OF ESTIMATING POPULATIONS OF THE SHEEP KED ON FEEDER LAMBS

Method	Number of lambs	Average number of keds per lamb	Correlation coefficient (r)	Regression coefficient (b_{xy})	Standard error of estimate (S_y)
"Total live count"	39	137.3 (14-448)†	+ 0.974*	1.485	48
5-minute count	21	39.2 (4-105)	+ 0.947*	4.824	51
Vertical-parting count (4-inch spacing)	21	19.2 (3- 82)	+ 0.959*	7.912	45
Method of Muma *et al.*	21	20.0 (1- 72)	+ 0.897*	8.187	70
"Picked-off" count	39	143.3 (14-595)	—	—	—

* Highly significant.
† Range of count.

the method does not allow time to complete the estimate when large sheep or heavy infestations are being assessed. The vertical-parting count has neither of the disadvantages of the 5-minute count and therefore should be applicable to mature sheep as well as to lambs.

The standard errors of estimate (Table 1) were not significantly different and indicated that the accuracies of the four methods are comparable. In the "total live count", significantly more keds were counted than in the other three methods. In the 5-minute count, significantly more keds were counted than in the vertical-parting count and the method of Muma *et al.*, the latter two methods showing no significant difference between each other. Data on these methods are being obtained for mature sheep and suckling lambs.

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NOTE ON A PHYSIOLOGICALLY ACTIVE PSEUDOUREA

The compound 3-(4-chlorophenyl)-1,1-dimethylurea (CMU) has been shown by Bucha and Todd (1) to be active as a plant growth inhibitor. It has been found that 3,3-di-(4-chlorophenyl)-2-methyl-pseudourea (I), which is similar in structure to CMU, has a comparable effect upon the growth of certain plant species. The latter compound was synthesized by Robinson and Brown (2).

The effects of CMU and I on foliage were compared by spraying four-weeks-old plants, such as purple cockle, shepherd's purse and broad-leaved dock, with 0.2 per cent solutions in acetone. After three weeks all plants showed signs of chlorosis at the tips of the leaves. There was no essential difference in the effect of the two compounds.

Pre-emergence tests on radish and timothy seeds have shown that CMU and I have similar effects in suppressing germination.

In order to evaluate the comparative effects of CMU and I on root growth, timothy seeds were floated on the surface of dilute aqueous solutions of the compounds and root lengths were measured at the end of seven days. At concentrations below 8 p.p.m., I stimulated the elongation of timothy roots, whereas suppression occurred at higher concentrations. CMU produced similar effects at concentrations approximately four times those of I.

It has been established that the LD_{50} of I to male white rats and to male Norway rats is 50 mgm./kgm. of body weight. CMU is reported (1) to have an LD_{50} of 3500 mgm./kgm.

The investigation is being continued.

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NOTE ON FACTORS AFFECTING THE LABORATORY EVALUATION OF SOIL CONDITIONERS*

The majority of the procedures reported in the literature for the routine laboratory evaluation of soil conditioners (1, 2) are based on the degree of stability of conditioned soil aggregates as measured by the wet-sieving technique of Yoder (3). The aggregates for these tests are prepared by mixing together finely ground soil, conditioner and water. The amount of water specified by different workers varies considerably. At lower moisture levels the mixture breaks up naturally into aggregates, whereas at higher moisture levels a pasty mass is formed from which aggregates are obtained by forcing through a sieve.

An investigation of these procedures in the laboratories of Canadian Industries Ltd., using a heavy clay soil, has shown them to yield markedly different results with variations in the manner of preparation of the aggregates. Particularly important is the initial moisture content of the aggregates and the method of addition of the conditioner. The response of any given conditioner to these variables is different and depends on its type.

Variations in aggregate stability in the test were also noticed with variations in the dryness of the aggregates and the ageing of the dry aggregates. However, these phenomena were observed with non-conditioned as well as conditioned soil and are believed to be essentially independent of the presence of conditioner.

Since the work showed that the efficiency of different conditioners with respect to one another was so dependent upon at least two variables, it was decided to check the results against procedures more closely simulating those which would be used in the field. The procedure devised differed from the routine procedure in that the conditioner was applied after, rather than prior to, the formation of aggregates. This coincides with recommended field practice. The aggregates were prepared from soil at a crumbly consistency, dried to varying degrees and the conditioner applied either as a powder or from a solution. In the powder application, additional water was added to assist solution of the conditioner but in no case was the moisture content of the soil taken beyond the crumbly state. It was observed that the method of adding the conditioner to the aggregates markedly affected the results. Much higher stability of the aggregates was obtained when the conditioner was applied to relatively dry aggregates which were subsequently wetted than when applied to damp or moist aggregates. Better structure was also obtained when the conditioner was applied from solution than as a powder. However, in every case, the values obtained for the stability of the conditioned aggregates were correlative with those from the routine test when the aggregates for the latter test were prepared from soil in a crumbly rather than a pasty or near pasty state.

* Subsequent to the completion of this work, an oral paper, "The laboratory evaluation of polyelectrolytes as soil conditioners", was presented by R. M. Hedrick at the September meeting of the American Chemical Society. His paper contains some of the findings reported in this Note.

In summary, the results stress the importance of (1) using only sufficient water in the preparation of the aggregates to yields oil of a crumbly consistency; (2) evaluating a conditioner in the form in which it is to be used; (3) adding the conditioners under test to the soil in an identical fashion, and (4) drying and ageing of the aggregates under standard conditions prior to wet-sieving.

A complete report is to be submitted later to this Journal for publication.

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